



HEWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

3444A

**MULTI-FUNCTION
UNIT**



— CERTIFICATION —

THE HEWLETT-PACKARD COMPANY CERTIFIES
THAT THIS INSTRUMENT WAS THOROUGHLY
TESTED AND INSPECTED AND FOUND TO
MEET ITS PUBLISHED SPECIFICATIONS WHEN
IT WAS SHIPPED FROM THE FACTORY.

 FURTHER CERTIFIES THAT ITS CALIBRATION
MEASUREMENTS ARE TRACEABLE TO THE
NATIONAL BUREAU OF STANDARDS TO THE
EXTENT ALLOWED BY THE BUREAU'S CALI-
BRATION FACILITY.

MANUAL CHANGES

MODEL 3444A

DC MULTIFUNCTION UNIT

Manual Serial Prefixed: 435

 Part No. 03444-90000

To adapt this manual to instruments with other serial prefixes check for errata below, and make changes shown in tables.

► New or revised item.

Instrument Serial Prefix	Make Manual Changes	Instrument Serial Prefix	Make Manual Changes
ALL	ERRATA		

NOTE: -hp- Part No. and -hp- Stock No. are synonymous.

ERRATA:

Figure 5-15, Amplifier Schematic:

A2C2 is polarized and the polarity is reversed.

P1 and J1 pin 16 is connected to sub-circuit ground .

Change pin numbers on Function switch S1A to: Wiper arm - 5, Volts - 1, ohms and amps - 6.

Figure 5-16, Function and Range Schematic:

Range Switch:

Change 100MA to 100 μ A.

Change S2C to S2E (reverse positions of S2L1 and S2C1).

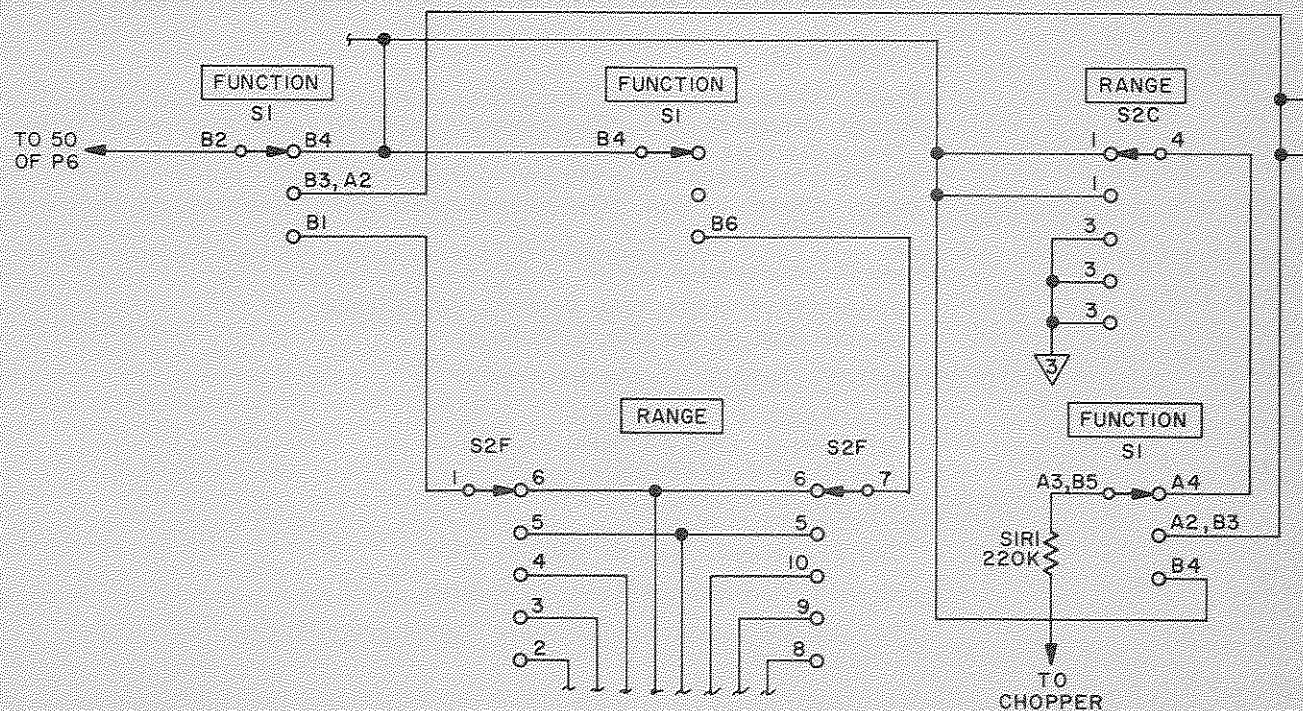
► Function Switch:

Change S1B to S1E (1 is connected to pin 3 of P6. 2 is connected to 28 of P6).

P2 and J2 pin 2 is connected to sub-circuit ground .

In some instruments the physical position of the Range switch is rotated 180 degrees.

Change input switching as shown in the following partial schematic.



► New or Revised Item
Instrument Serial Prefix

Make Manual Changes

Instrument Serial Prefix

Make Manual Changes

ALL	ERRATA		

ERRATA:

Table 1-1, Specifications:

Resistance Accuracy: Change to read $\pm 0.3\%$ of reading ± 1 digit up to 10 meg range and $\pm 1\%$ of reading ± 1 digit on the 10 meg range for line variations of $\pm 10\%$ from nominal (0 to 50°C).

Common Mode Rejection: Change * to read Error $< 0.1\%$ of full scale.

Response Time: Delete "within" before 99.95% in all cases.

Input Filter AC Rejection: 100 and 1000 mv ranges,

Change 50 mv to 40 mv;

Change 500 mv to 400 mv.

Section V, Paragraph 5-31, steps d, i, n, and q:

Change ± 21 counts to ± 10 counts.

Section V, Paragraph 5-32, step b:

Change to read:

Use the resistors and ranges in Table 5-8. Observe the reading on the 3440A with the DC Standard turned off. Turn the DC Standard output switch on, applying 500 volts between common and chassis ground (3440A). The readout should not vary more than ± 10 counts. Set the Audio Oscillator to 60 cycles ten volt output p-p (3.5 volts rms). Use the resistors and ranges in Table 5-8. Connect the Audio Oscillator between common and chassis ground of the 3440A input terminal. With and without the Audio Oscillator signal, the readout should not vary more than ± 10 counts.

Table 5-8:

Delete the section called "Tolerance of 3440A Readout with 500 vdc or 3.5 vac".

Paragraph 5-34:

Step f: Change 50 mv p-p (18 mv rms) to 40 mv p-p (14 mv rms).

Step g: Change to read, "The readout on the 3440A should change not more than ± 10 counts."

Step h: Change 180 mv to 140 mv.

Step i: Change to read, "The readout on the 3440A should change not more than ± 10 counts."

Section VI, Replaceable Parts:

Change A3R15, A3R16 to ϕ Part No. 03444-82602.

Add Heat Sink, ϕ Part No. 1205-0011.

► Figure 5-15, Amplifier Schematic (cont'd)

S2C and S2D, RANGE switch:

Interchange 1000 MV and 100 MV.

Add P6 pin 44 is connected to $\frac{1}{2}$

P6 pin 20 is connected to 19.

S1C FUNCTION switch:

Delete connection to 2 in AMP position

► Figure 5-16, Function and Range Schematic:

S2F, RANGE switch (portion where 7 is connected to ∇)

Change F to E.



OPERATING AND SERVICING MANUAL

MODEL 3444A

SERIALS PREFIXED 435-

DC MULTI-FUNCTION UNIT

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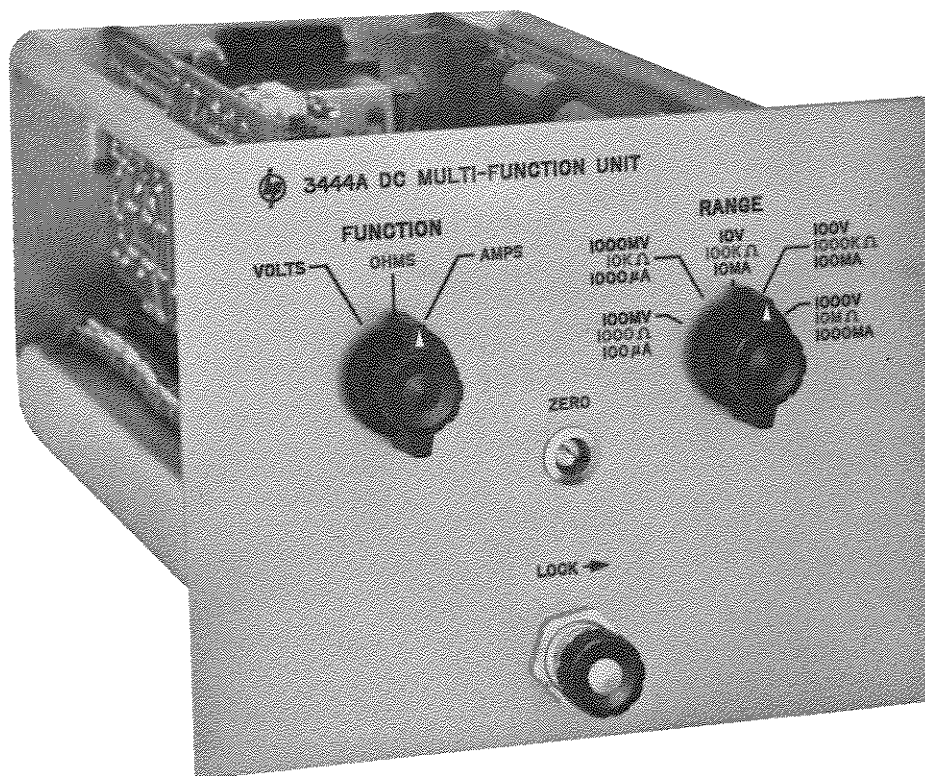


Figure 1-1. Model 3444A Multi-Function Meter

Table 1-1. Specifications

Table 1-1. Specifications

VOLTAGE RANGES: 4-digit full-scale presentations of 99.99 mv, 999.9 mv, 9.999 volts, 99.99 volts, and 999.9 volts with 5% overrange capability and overrange indication.

CURRENT RANGES: 4-digit full-scale presentations of 99.99 μ a, 999.9 μ a, 9.999 ma, 99.99 ma, and 999.9 ma with 5% overrange capability and overrange indication.

RESISTANCE RANGES: 4-digit full-scale presentations of 999.9 ohms, 9.999 K ohms, 99.99 K ohms, 999.9 K ohms, and 9.999 M ohms with 5% overrange capability and overrange indication.

VOLTAGE ACCURACY: 9.999 v to 999.9 v (full scale):

- $\pm 0.05\%$ of reading ± 1 digit including line voltage variations of $\pm 10\%$ from nominal and temperature variations from $+15^{\circ}\text{C}$ to $+40^{\circ}\text{C}$;
- $\pm 0.1\%$ ± 1 digit for temperature variations from 0°C to $+50^{\circ}\text{C}$.

99.99 mv and 999.9 mv (full scale):

- $\pm 0.1\%$ of reading ± 1 digit including line voltage variations of $\pm 10\%$ from nominal range between $+15^{\circ}\text{C}$ and $+40^{\circ}\text{C}$; $\pm 0.15\%$ ± 1 digit for temperature range of 0°C to $+50^{\circ}\text{C}$.

CURRENT ACCURACY: $\pm 0.2\%$ of reading ± 1 digit for line variations of $\pm 10\%$ from nominal (0 to 50°C)

RESISTANCE ACCURACY: $\pm 0.3\%$ of reading ± 1 digit from 999.9 Ω to 999.9 K Ω and $\pm 1\%$ of reading ± 1 digit on 9.999 megohm range for line variations of $\pm 10\%$ from nominal. (0 to 50°C)

OHMMETER CURRENT:

Range	Short Circuit Current
1 K	1 ma
10 K	100 μ a
100 K	10 μ a
1 M	1 μ a
10 M	0.1 μ a

RANGE: manual.

VOLTMETER INPUT IMPEDANCE: constant 10.2 megohms (to dc) all ranges.

AMMETER INPUT RESISTANCE:

Range	Input Resistance
100 μ a	1000 Ω
1000 μ a	100 Ω
10 ma	10 Ω
100 ma	1.3 Ω^{**}
1000 ma	0.4 Ω^{**}

****Includes .3 Ω wiring resistance.**

POLARITY: automatic indication.

COMMON MODE REJECTION:

Voltage:	DC	60~
100 mv	130 db	<10 v p-p*
1000 mv	110 db	<10 v p-p*
10 v	90 db	70 db
100 v	70 db	50 db
1000 v	50 db	30 db

SECTION I

GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The ϕ Model 3444A DC Multi-Function Unit and the ϕ Model 3440A Digital Voltmeter combination measures dc volts, dc amps or ohms with four-digit resolution. RANGE and FUNCTION are selected manually.

1-3. This combination has five voltage ranges with full-scale readout from ± 99.99 millivolts to ± 999.9 volts. The five ohmmeter ranges extend from a minimum full-scale reading of 999.9 ohms to a maximum full-scale reading of 9.999 megohms. The five ammeter ranges extend from a full-scale readout of 99.99 microamps to 999.9 milliamps.

1-4. PLUG-IN VARIATIONS.

1-5. The standard Model 3444A may be used in conjunction with a printer using a 1-2-2-4 code. If a printer with a 1-2-4-8 code is used, both the  Model 3440A and the 3444A Plug-In must be converted for this

code. Converted instruments become specials, identified by an alpha-numeric prefix to the model number (i. e. H02-3444A). This number may be engraved on the front panel or on a permanent sticker on the rear panel.

1-6. INSTRUMENT IDENTIFICATION.

1-7. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 3444A described in this manual.

1-8. If E or G prefixes the serial number, the instrument is manufactured in Europe (E for England and G for Germany). These instruments are provided with manual change sheets if necessary to explain differences between the instrument and manual.

Table 1-1. Specifications (Cont'd)

COMMON MODE REJECTION (Cont'd):			RESPONSE TIME:			
Current:			Voltage:			
	DC	60~	less than 450 ms to within 99.95% of final value for full-scale step function on 10, 100, and 1000 volt ranges.			
100 μ a	<500 vdc*	<3 v p-p*	less than one second to within 99.95% of final value for a full-scale step function on 100 and 1000 mv ranges.			
1000 μ a	<500 vdc*	<10 v p-p*				
10 ma	<500 vdc*	<10 v p-p*				
100 ma	<500 vdc*	<10 v p-p*				
1000 ma	<500 vdc*	<10 v p-p*				
Resistance:			Current:			
	DC	60~	less than one second to within 99.95% of final value for a full-scale step function on all current ranges.			
1 K ohm	<500 vdc*	<10 v p-p*				
10 K ohm	<500 vdc*	<10 v p-p*				
100 K ohm	<500 vdc*	<10 v p-p*				
1000 K ohm	<500 vdc*	<10 v p-p*				
10 M ohm	<500 vdc*	<10 v p-p*				
*Unit meets specified accuracy under these conditions.			Resistance:			
			less than 1.0 seconds to within 99.95% of final value except for the 10 M ohm range.			
			less than 5.0 seconds to within 99.95% of final value for the 10 M ohm range.			
AC REJECTION:			WEIGHT:			
Voltage:			Net		Shipping	
10, 100, and 1000 volt ranges: 30 db at 60 cps, increasing 12 db/octave.			lbs.	Kg	lbs.	Kg
100 and 1000 mv ranges: maximum of 50 mv and 500 mv p-p respectively at 60 cps for rated accuracy.			3.0	1.35	6.5	2.9
Current:			DIMENSIONS: 6" (12.25 cm) wide, 4-11/16" (11.90 cm) high, 9-1/8" (23.15 cm) long.			
60 cps p-p ripple current may be up to 50% of the full-scale current for rated accuracy.						

NOTES

SECTION II

INSPECTION AND INSTALLATION

2-1. INCOMING INSPECTION.

2-2. This instrument was carefully inspected both mechanically and electrically before shipment. It should be free from marks or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Also check for supplied accessories, and test the electrical performance of the instrument using the procedure outlined in Paragraph 5-5. If there is damage or a deficiency, see the warranty on the inside rear cover of this manual.

2-3. INSTALLATION.

2-4. Install the Model 3444A in the compartment provided in the Φ Model 3440A Digital Voltmeter. Make certain the 3444A is inserted properly and the front panel locking screw is tightened.

2-5. REPACKAGING FOR SHIPMENT.

2-6. The following is a general guide for repacking an instrument for shipment. If you have any questions, contact your local Sales and Service Office (see maps in Appendix for location).

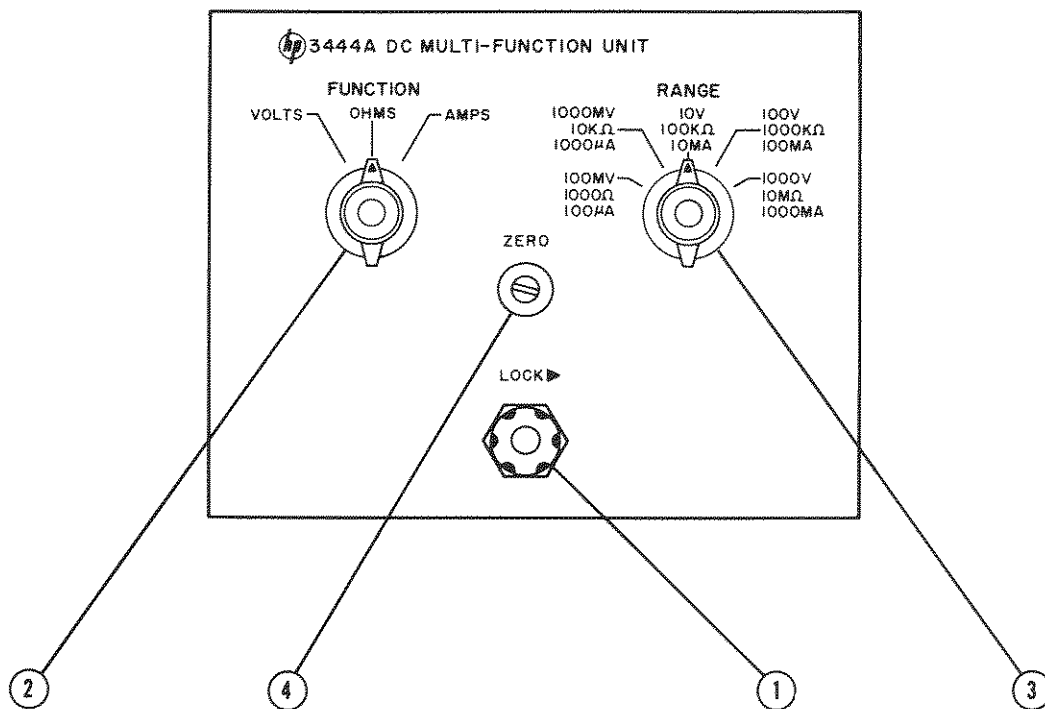
- a. Place instrument in original container if available. If not available, it may be purchased from your nearest Φ Sales and Service Office.

If original container is not used,

- b. Wrap instrument in heavy paper or plastic before placing in inner container.
- c. Use plenty of packing material around all sides of instrument and protect panel faces with cardboard strips.
- d. Use a heavy carton or wooden box to house the instrument and inner container and use strong tape or metal bands to seal the shipping container.
- e. Mark shipping container with "Delicate Instrument," "Fragile" etc.

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach to the instrument a tag identifying the owner and indicating the service or repair to be accomplished; include the model number and full serial number of the instrument.



1. LOCK: When turned to the right, the Model 3444A is locked securely in the compartment of 3440A.
2. FUNCTION: This switch provides for manual selection of three functions: volts, ohms, and amps.
3. RANGE: This switch provides for five ranges for each function. For an input signal of the value labeled on the switch, the first digit is not shown and the Model 3440A overrange light is lit. (100 v input on the 100 v range reads "over-range" 00.00.)
4. ZERO: The ZERO adjust sets the Model 3440A readout for a zero reading with input shorted on the 100 MV range and on all current ranges.

Figure 3-1. Model 3444A Controls

SECTION III OPERATION

3-1. GENERAL.

3-2. The Model 3444A DC Multi-Function Unit has a three-position function switch and a five-position RANGE switch located on the front panel (see Figure 3-1. The ZERO screwdriver adjustment on the front panel of the 3444A is for adjusting the 100-milivolt range and all current ranges.

3-3. OPERATING PROCEDURE.

3-4. Operating instructions for the Model 3444A Multi-Function Unit are given in Figure 3-2. Instructions

are keyed to the illustration of the front panel of the 3440A and 3444A Plug-In.

3-5. APPLICATIONS.

3-6. The sensitivity, input resistance, and resolution of the instrument (see Specifications Table 1-1) make the Model 3444A useful for measuring voltages and currents of thermocouples and other transducers. The high accuracy, versatility, and speed make it a very useful general purpose laboratory instrument for measuring dc volts, ohms, and amps.

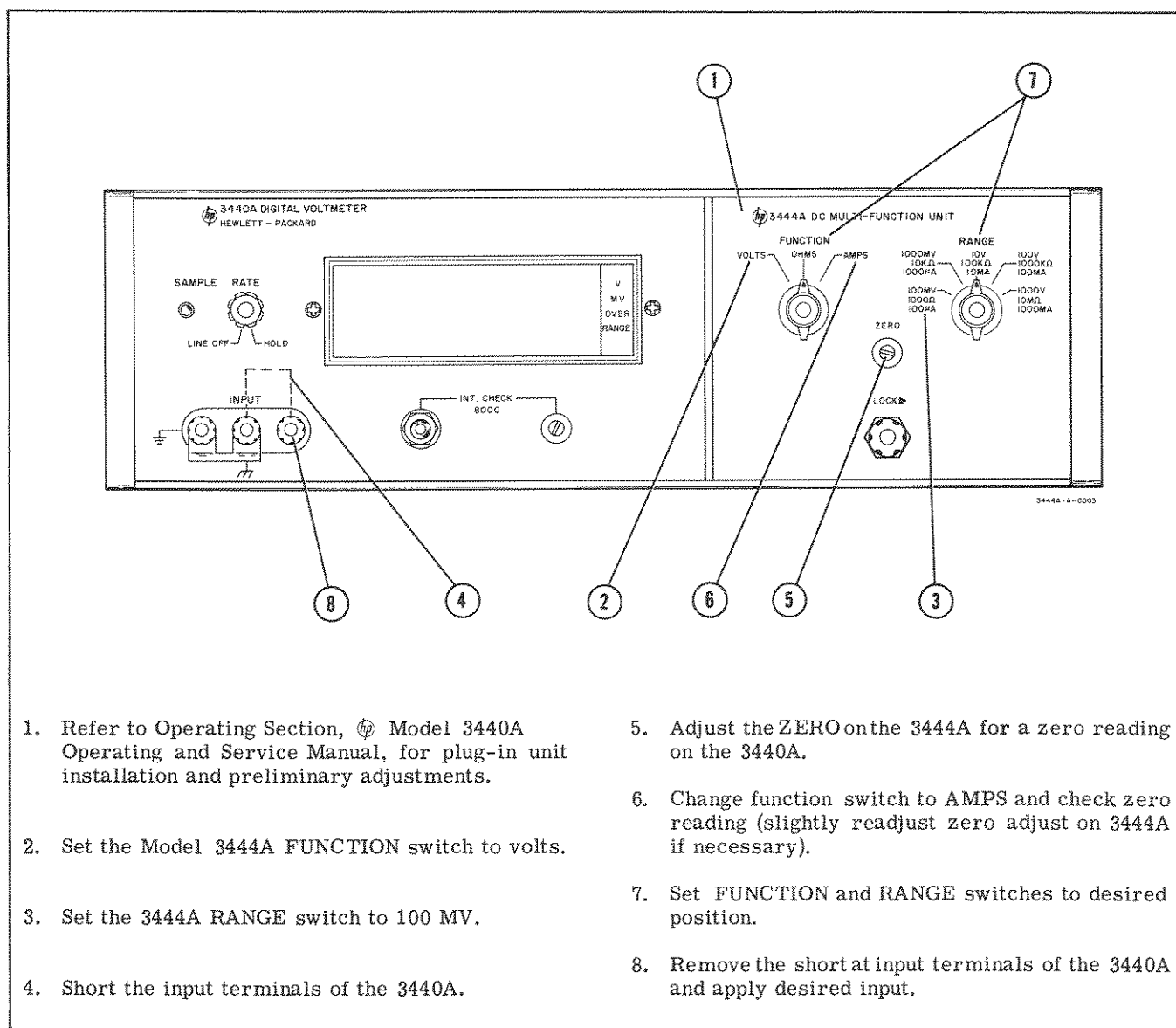


Figure 3-2. Operation

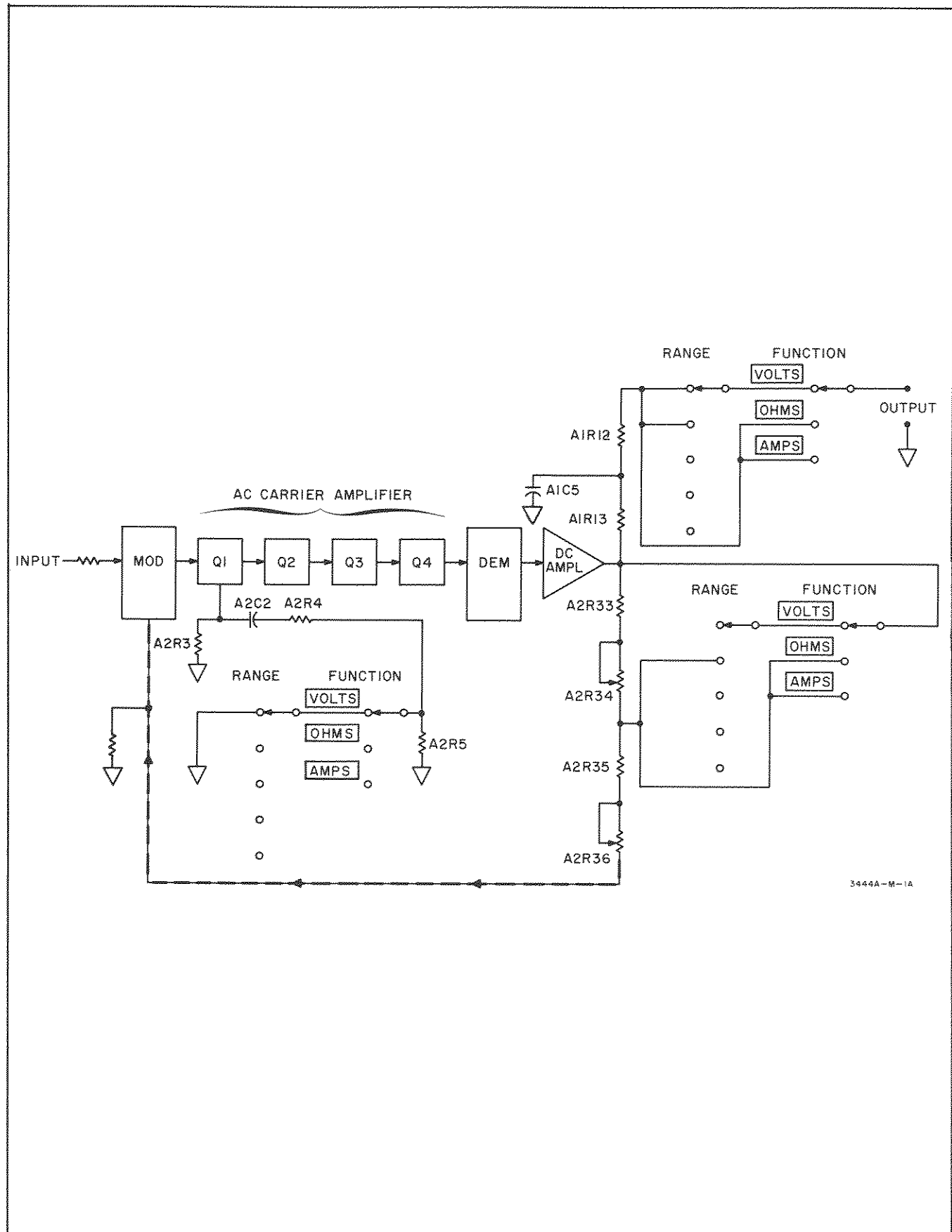


Figure 4-1. Amplifier Block Diagram

SECTION IV

THEORY OF OPERATION

4-1. GENERAL.

4-2. The Model 3440A, when used with the Model 3444A, is capable of the following measurements: 1) DC Volts, 2) DC Ohms, and 3) DC Amps. Each type of measurement requires a precise voltage at the comparator network of the Model 3440A.

4-3. The Model 3440A comparator network is adjusted for a full-scale indication for a ten-volt input. Input signals are attenuated, amplified, or fed directly to the comparator by the 3444A for correct indications by the 3440A. The amplifier section of the 3444A is used for all current ranges, the 100 mv range, the 1000 mv range, and for all ohm measurements.

4-4. OVERALL AMPLIFIER DESCRIPTION.

4-5. A simplified block diagram of the amplifier section is shown in Figure 4-1. The amplifier gain is controlled by the manual switches for the various functions and ranges.

4-6. A dc input voltage is applied to the amplifier section. The modulator converts the dc voltage to an ac voltage for amplification. This ac voltage is amplified by the four-stage ac amplifier, Q1 through Q4. The amplified signal is then demodulated, converting the ac signal back to dc. This dc signal is applied to a dc amplifier (Q5, Q6, and Q7) for further amplification. A portion of the dc amplifier output voltage from the collector of Q7 is fed back to the front of the amplifier.

4-7. MODULATOR AND DEMODULATOR OPERATION.

4-8. The modulator-demodulator circuit consists of a neon lamp relaxation oscillator and four photoconductors, A4V1 through A4V4. The relaxation oscillator contains three lamps A4DS1 through A4DS3. The sequence for ionizing the lamps is: A4DS1, A4DS2, A4DS3, A4DS2, A4DS1 etc. The first lamp to light will remain lit until the second one reaches its firing potential. At this time, the second lamp will light and the first one goes out. In the same manner, the third lights when the second one goes out, and the second one lights again when the third goes out etc. The frequency of the oscillator, approximately 200 cycles per second, is controlled by the potentiometer A1R9. Lamp A4DS1 simultaneously illuminates A4V1 and A4V3; lamp A4DS3 illuminates A4V2 and A4V4; lamp A4DS2 is located so that it does not illuminate any of the photoconductors. This creates a rest period after each pair of photoconductors is illuminated enabling the photoconductors to recover to a high resistance state before the other photoconductors are illuminated.

4-9. MODULATOR.

4-10. The modulator (A4V1 and A4V2) converts the dc input voltage to ac for amplification. The dc input voltage is applied to one side of the modulator and the feedback voltage is applied to the other side. The voltage at the output of the modulator is alternately at the feedback voltage or the input voltage depending on which photoconductor, A4V1 or A4V2, is in the low resistance state. The ac signal at Q1 is a square wave with a peak-to-peak amplitude of the difference between the input voltage and the feedback voltage. A2CR1 and A2CR2 are overload protection devices that limit the modulator input voltage to that of a forward-biased silicon diode.

4-11. AC AMPLIFIER.

4-12. The ac amplifier is a four-stage dc coupled amplifier consisting of A2Q1 through A2Q4. The input is capacitively coupled from the modulator and the output is capacitively coupled to the demodulator.

4-13. The dc feedback path from the collector of A2Q3 through A2R13 and A2R1 to the base of A2Q1 is for the purpose of biasing. Feedback from the collector of A2Q4 through A2R14 and A2R8 to the emitter of A2Q1 increases the ac input impedance to approximately 1 megohm and sets the ac voltage gain. A2CR1 sets the collector-emitter voltage of A2Q2 at approximately 1.3 volts. A2CR2 and A2R16 maintain proper biasing for A2Q4. A2CR4 and A2CR5 are inserted to prevent overcharging of A2C9 and provide quick recovery when an overload is applied to the input. A2CR4 and A2CR5 are connected to the voltage divider to prevent reversal of polarity on A2C9. This voltage across C9 is about 0.3 volts under normal operation.

4-14. DEMODULATOR AND DC AMPLIFIER.

4-15. The demodulator (A4V3 and A4V4) converts the amplified ac signal to a dc voltage which is amplified further by the dc amplifier. Operation of the demodulator is similar to that of the modulator. A4V3 and A4V4 are alternately illuminated by A4DS1 and A4DS3. When A4V3 conducts, A2C7 charges. When A4V4 conducts, A4V3 offers high impedance. This action results in a dc voltage output with the same polarity as the input dc voltage.

4-16. The dc amplifier A2Q5, A2Q6, and A2Q7 is directly coupled. The bias on A2Q6 is determined by potentiometer A2R31 (1000 mv zero adjustment). A2CR7 provides a regulated 20-volt supply for the dc amplifier. A2CR6 sets the drop across A2R25 at approximately 6 volts. The output of A2Q7 goes to the comparator in the Model 3440A and also furnishes feedback to the modulator.

Section IV
Paragraphs 4-17 to 4-27 and Figure 4-2

4-17. OPERATION OF VOLTMETER.

4-18. The voltage output of the Model 3444A, for full-scale readout in any range, is ten volts. The input voltage is amplified by the amplifier section for the 100 mv and 1000 mv ranges, attenuated by the voltage divider for the 10 v and 1000 v, and fed straight through for the 10 v range. (See the Voltmeter Block Diagram, Figure 4-2.

4-19. The amplifier loop gain is held constant for both the closed loop gain of 10 (1000-millivolt position) and of 100 (100-millivolt position). This is accomplished by shorting out A2R5 in the 100-millivolt position, which increases the gain of Q1 enough to compensate for the increased attenuation in the feedback network (A2R33 and A2R34).

4-20. For the 100- and 1000-volt ranges, the manual range switch connects to the proper tap on the voltage divider in the 3440A. (See 3440A manual for attenuator adjustments.)

4-21. Consider application of a dc signal to the input terminals on the 100 MV range. This input signal passes through resistors S1R1 and R1 to the input side of photocell A4V1. Simultaneously, 1/98 of the output signal at TP3 is fed back via the voltage divider, consisting of A2R33, R34, R35, R36, R6, and R7, to the bottom of photocell A4V2. The difference, or error, between these two dc signals (input signal and feedback signal) is converted to an ac signal (nominally 200 cps) by photocells A4V1 and A4V2, which perform as a half-wave modulator.

4-22. The resulting ac signal is applied to the base of A2Q1. The voltage gain from the base of A2Q1 to collector of A2Q4 is set by resistors A2R14, R11, R8, R3, and R7 on this range and is approximately 30,000. The resulting ac signal at the collector of A2Q4 is converted to dc by the half-wave demodulator A4V3 and A4V4. This dc current changes the dc level across capacitor A2C9. This voltage change is applied to the base of A2Q5 and is further amplified by the

action of A2Q5, Q6, and Q7. A2Q5, Q6, and Q7 form a direct-coupled dc amplifier with a gain of about 36, set by A2R26 and R27. The open loop dc gain (output voltage at TP3 divided by input error voltage) is then $30,000 \times 36 \times$ efficiency of modulator and demodulator or about 200,000. Since this gain is much higher than the required closed loop gain (the voltage at TP3 divided by the input voltage), a low-error voltage is assured.

4-23. The output voltage at TP3 is transmitted through the low-pass filter A1R12, A1C5, and A1R13 to the comparator of the 3440A.

4-24. The decimal point and the volt or millivolt light are obtained for each range by the manual switches. The center decimal light is enabled by grounding pin 2 of P6, and the left decimal light is enabled by grounding pin 1 of P6. When neither the left decimal point nor the center decimal point is lit, the right decimal is enabled. The millivolt light is enabled by grounding pin 26 of P6, when pin 3 of P6 is connected to -150 volts. The volt light is enabled if the millivolt light is not enabled and pin 3 of P6 is connected to -150 volts. Polarity is controlled by the 3440A comparators and may be disabled by disconnecting pin 5 of P6 from the +150 volt supply.

4-25. Printer information for function and range are provided by the manual switches. Printer overrange indication comes from the 3440A on pin 9 of P6 and controls the required printer functions through diodes A1CR3 to A1CR6.

4-26. OPERATION OF OHMMETER.

4-27. The ohmmeter has five ranges. The maximum full-scale resistance readout on each range is: 999.9 ohms, 9.999 K ohms, 99.99 K ohms, 999.9 K ohms, and 9.999 megohms. The ohmmeter uses the amplifier section of the Model 3444A for each range. This amplifier has been previously described in Paragraphs 4-5 to 4-16.

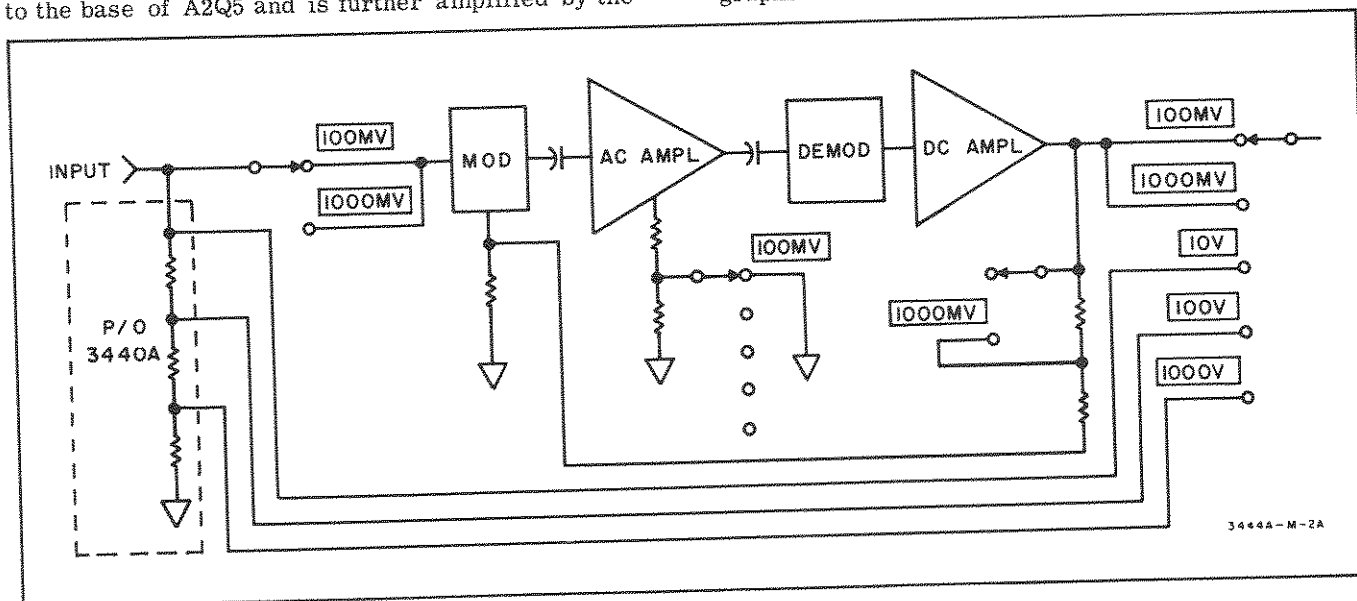


Figure 4-2. Voltmeter Block Diagram

4-28. The ohmmeter reference voltage is controlled by the reference voltage supply consisting of Q1, Q2, Q3, CR1 and Resistors R12 through R22 on the A3 printed circuit board. Q1 and Q2 are connected as a differential amplifier and control the voltage at the emitter of Q3. This reference voltage is set to approximately -20 volts. Coarse adjustment is accomplished by shorting out or adding resistors A3R12 through A3R14 and the fine calibration is accomplished by adjusting the variable resistor A3R18.

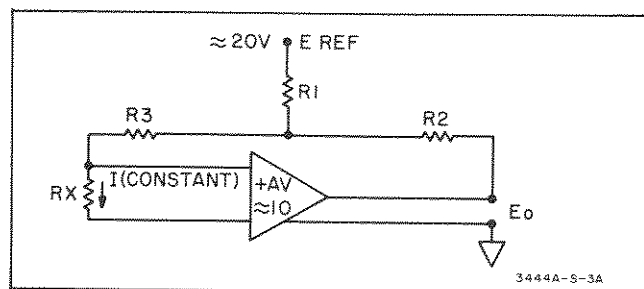


Figure 4-3. Ohmmeter Block Diagram

4-29. A simplified diagram for the ohmmeter section of the 3444A is found in Figure 4-3. A constant current is driven through R_x causing the voltage developed across R_x to be directly proportional to the unknown resistance. The input resistance of the amplifier is extremely high and the output impedance is low. If R_x is increased, the voltage developed across R_x will be more negative. This negative voltage will be amplified 10 times and enough of this output voltage is fed back to the input to hold the current through R_x at a constant value.

4-30. The mathematical equation expressing the output voltage for the configuration shown in Figure 4-3 is:

$$E_o = \frac{Av E_{ref} R_1 R_x}{R_1 R_2 + R_2 R_3 + R_1 R_3 + [R_1 + R_2 (1 - Av)] R_x}$$

assuming: the amplifier input resistance $\gg R_x$;
the output resistance of the amplifier is small.

If R_2 is selected so that $R_1 + R_2 (1 - Av) = 0$, the expression reduces to:

$$E_o = \frac{Av E_{ref} R_1 R_x}{R_1 R_2 + R_2 R_3 + R_1 R_3}$$

Values for E_{ref} , R_3 , R_2 and R_1 , are selected to give full-scale voltage output for full-scale R_x .

By attenuating E_{ref} and changing the values of R_1 , R_2 and R_3 for different ranges, a full-scale readout is obtained for full-scale R_x on each range. (See Figure 5-11.)

4-31. The 3440A readout with the 3444A Multi-Function Unit in the ohms position indicates four digits, with no polarity sign or function indication. The decimal point and printer information are controlled by the manual range and function switches.

4-32. OPERATION OF AMMETER.

4-33. Refer to Figure 4-4 throughout this explanation. Currents from 99.99 microamps to 999.9 milliamps, full-scale readout, may be measured with the 3440A/3444A combination.

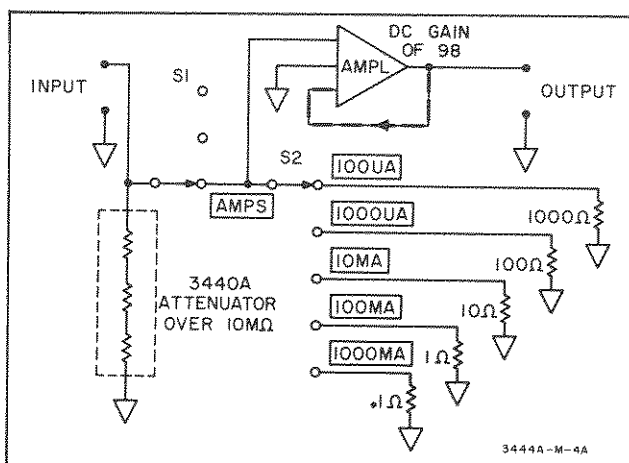


Figure 4-4. Ammeter Block Diagram

4-34. A precision resistor is shunted across the input of the amplifier for each current range. The voltage developed across this shunt resistor is 99.99 mv for full-scale readout in each range. See the amplifier Block Diagram, Figure 4-1, and the Schematic Diagram, Figure 5-15, for ammeter switch diagrams.

4-35. The instrument input resistance is largely dependent on the different shunts used for the various ranges. Table 4-1 shows the approximate input resistance.

Table 4-1. Ammeter Input Resistances

Range	Input Resistance
100 μ a	1000 Ω
1000 μ a	100 Ω
10 ma	10 Ω
100 ma	1.3 Ω
1000 ma	0.4 Ω

*The instrument wiring resistance is approximately .3 Ω .

Table 5-1. Test Equipment Required

Instrument Type	Critical Specifications	Use	Recommended Model
Autotransformer	Output adjustable from 0 v to 140 v 0 v to 280 v at approximately 30 watts	Performance Check/ Adjustment Pro- cedure	Powerstat type 3PF116 type 3PF216
DC Voltage Standard/Dif- ferential Volt- meter	0 to 1000 v, 50 ma, 0.01% accuracy	Performance Check/ Adjustment Pro- cedure	Ⓢ Model 740A
DC Power Sup- ply	0 to 60 vdc, regulated, 0 to 2 A	Performance Check/ Adjustment Pro- cedure	Ⓢ Model 726AR
Digital Recorder	1-2-2-4 code	Performance Check/ Adjustment Pro- cedure	Ⓢ Model 562A
Precision Re- sistors	0.02% or better 0.1 Ω 10 Ω *1 K Ω *500 Ω 10 K Ω *1 M Ω 100 Ω	Performance Check/ Adjustment Pro- cedure	Leeds and Northrup 4907 Stenton Avenue Philadelphia, Pa. LN Model 4221-B Ⓢ Stock No. 0811-0396 Ⓢ Stock No. 0811-0402 RLC resistors General Radio Co. order by value and % of tol.
Resistor	1 M, 1/2 w, 1% C/C	Performance Check/ Adjustment Pro- cedure	Ⓢ Stock No. 0727-0275
Resistor	10 Ω , 10 w	Performance Check/ Adjustment Pro- cedure	Ⓢ Stock No. 0816-0010
Resistors	4.5 M Ω , 0.2% tol, quantity 2		Ⓢ Stock No. 0811-0023
DC Voltmeter	1 mv to 1000 v range; 2 megohm input impedance	Adjustment Procedure	Ⓢ Model 412A
DC Microvolt- Ammeter	0.3 μ a to 3 ma range 10 μ a to 1 v range	Performance Check	Ⓢ Model 425A
AC Voltmeter	10 mv to 300 v range; 2 meg input im- pedance; $\pm 1\%$ at 200 cps	Adjustment Procedure	Ⓢ Model 403B
AC Current Probe	1 mv/ma Max input 1 amp rms Accuracy $\pm 5\%$ at 60 cps	Performance Check	Ⓢ Model 456A
Low Frequency Electronic Counter	0 to 200 cps ± 1 cps accuracy	Adjustment Procedure	Ⓢ Model 522B
50 MC Oscillo- scope	Bandwidth: dc to 50 Mc Sensitivity: 0.1 v/cm to 20 v/cm	Troubleshooting	Ⓢ Model 175A 50 MC Oscilloscope
Wide Range Oscillator	5 cycles to 600 Kc	Performance Check	Ⓢ Model 200CD
Mercury Bat- tery	1.34 volt	Performance Check	Ⓢ Stock No. 1420-0010
Potentiometer	1 K 10 turn	Performance Check	Clarostat 62JA-1K
Soldering Iron and Tips	50 watts; min tip temp 700°F; TP size OD 1/16" to 3/32"	Repair	Ungar #776 Soldering Iron Handle Ungar #PL333 tiptlet Ungar #854 cup tip

*More conveniently obtainable values or a decade resistance box may be used if the tolerance is 0.02% or better.
**Test equipment other than that recommended may be used if the specifications are equal to or exceed those listed.

SECTION V MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains maintenance and service information for the Model 3444A DC Multi-Function Unit. Included is a performance check, an adjustment and calibration procedure, and a troubleshooting procedure.

5-3. TEST EQUIPMENT REQUIRED.

5-4. Test equipment required for the performance check and the adjustment and calibration procedure is listed in Table 5-1, Test Equipment Required. Test instrument type, critical specifications, use, and recommended models are included in the table.

5-5. PERFORMANCE CHECKS.

5-6. The performance checks are designed to check the Model 3444A against its specifications. The performance checks should be performed upon receipt of the instrument, following repairs, and as a part of periodic maintenance. No adjustments should be made internally on the instrument during the performance checks. If the instrument fails to meet a series of specifications (such as voltage, resistance, or current specifications), an appropriate section of the adjustment and calibration procedure is referenced for corrective action. Before checking the 3444A, the performance checks should be made on the 3440A using the procedure outlined in Section V of the Model 3440A Operating and Service Manual.

5-7. TEST CONDITIONS.

5-8. The following test conditions must be followed. During the entire performance checks, the ambient temperature must be maintained between $+15^{\circ}\text{C}$ and $+40^{\circ}\text{C}$.

5-9. VOLTMETER CALIBRATION ACCURACY.

5-10. Install the Model 3444A in the plug-in compartment of the Model 3440A.

5-11. TEST SETUP.

- a. Connect the Model 3440A to a source of ac power using the powerstat or adjustable autotransformer (115/230 v).
- b. Connect the output of the DC Standard to the input terminals of the Model 3440A. Set the output to zero.
- c. Allow both instruments to warm up for a period of 1/2 hour.

5-12. TEST PROCEDURE.

- a. Adjust SAMPLE RATE for suitable display.
- b. Place FUNCTION switch in VOLTS position and RANGE switch in 10 V position. Short INPUT terminals. Adjust Model 3440A ZERO (located on the back panel) control for 0.000 indication.
- c. Depress INT. CHECK and adjust, if necessary, for an indication of 8000.
- d. Place RANGE switch in 100 MV position. Short the input terminals of the 3440A. Adjust the Model 3444A ZERO control on the front panel for 00.00 indication. (Remove short.)
- e. Refer to Table 5-2, Voltage Calibration Checks, and adjust the voltage standard to the values listed noting the readings on the 3440A readout at each new setting of the voltage standard. The readings obtained must be within the tolerances listed in the table.

Table 5-2. Voltage Performance Checks

3444A RANGE Selector	DC Standard OUTPUT	Tolerance of 3440A Reading ($+15^{\circ}\text{C}$ to $+40^{\circ}\text{C}$)
± 100 mv	90.00 mv	89.90 to 90.10 mv
± 100 mv	50.00 mv	49.94 to 50.06 mv
± 100 mv	10.00 mv	09.98 to 10.02 mv
± 1000 mv	900.0 mv	899.0 to 901.0 mv
± 1000 mv	500.0 mv	499.4 to 500.6 mv
± 1000 mv	100.0 mv	099.8 to 100.2 mv

- f. Repeat step e with powerstat set for low line 103/206 v.
- g. Repeat step e with powerstat set for high line 127/254 v. If the tolerances are not met, refer to Paragraph 5-41 of this manual. Calibration procedure for 10 v, 100 v, and 1000 v ranges are given in Section V of the Model 3440A Operating and Service Manual.
- h. This completes the voltmeter calibration checks. Set the powerstat or adjustable autotransformer for a nominal input of 115/230 v to the Model 3440A and disconnect the voltage standard.

5-13. OHMMETER CALIBRATION ACCURACY.

5-14. The high-precision resistors listed in Table 5-1 are required for performance checks of the ohmmeter circuits.

5-15. TEST SETUP.

- a. Due to the high accuracy of the Φ Model 3444A/3440A, care must be used to avoid inaccuracy due to lead resistances on the lower ranges. Minimize the effect of contact resistance,

5-16. TEST PROCEDURE.

- a. Place the FUNCTION selector in the OHMS position and the RANGE selector in the 10 K Ω position. Place a 10 K Ω precision resistor across the input terminals of 3440A. Using Table 5-3, Ohmmeter Performance Checks, for reference, measure the resistance of the 10 K ohm high-precision resistor, noting whether the instrument indications are within the tolerances given. As each measurement is taken, the nominal line voltage to the 3440A should be adjusted to 103/206 v and 127/254 v. Repeat the procedure for each range listed in Table 5-3. (Nine M Ω is made up of two 4.5 M Ω resistors.) The instrument indications should remain within the tolerances given. If they do not, refer to Paragraph 5-43.

Table 5-3. Ohmmeter Performance Checks

3444A RANGE Selector	Precision Resistance*	Tolerance of 3440A Indication (+15°C to +40°C)
10 K Ω	10.0 K Ω	9.969 to 0.031 K Ω
10 M Ω	9 M Ω	8.909 to 9.091 M Ω
100 K Ω	100 K Ω	99.69 to 00.31 K Ω
1000 Ω	100 Ω	099.6 to 103.1 Ω
	500 Ω	498.4 to 501.6 Ω
	1000 Ω	996.9 to 003.1 Ω
1000 K Ω	1 M Ω	996.9 to 003.1 K Ω

5-17. AMMETER CALIBRATION ACCURACY.

5-18. The ammeter performance checks require the use of a DC Power Supply and a Differential Voltmeter (refer to Table 5-1 for specifications) in addition to the previously used setup. The following precision resistors are also required: 0.1 Ω , 10 Ω , and 10 K Ω . Ammeter adjustment and calibration procedures are given in Paragraph 5-44.

5-19. TEST SETUP.

- a. Connect the test setup shown in Figure 5-1, Ammeter Calibration Check Setup. Place the ten-ohm, ten-watt resistor listed in Table 5-1 as a current limiting resistor.

5-20. TEST PROCEDURE.

- a. Place the FUNCTION selector in the VOLTS position and the RANGE selector in the 100 MV position. Short the input terminals of the Model 3440A and note that indication is still 00.00 $\pm$ 0.01. If necessary, adjust the ZERO control on the front panel. Place the FUNCTION selector in the AMPS position and the RANGE selector in the 100 μ A position. Remove short on input.
- b. Using a 10 K Ω resistor in the test setup, adjust the DC Power Supply to obtain 1 volt as read on the Differential Voltmeter. An indication should be obtained within the tolerance given in Table 5-4 (+99.79 to overrange +00.21). Set the adjustable autotransformer for a nominal voltage of 103/206 v and 127/254 v and note that the indication remains within the tolerances shown in Table 5-4.

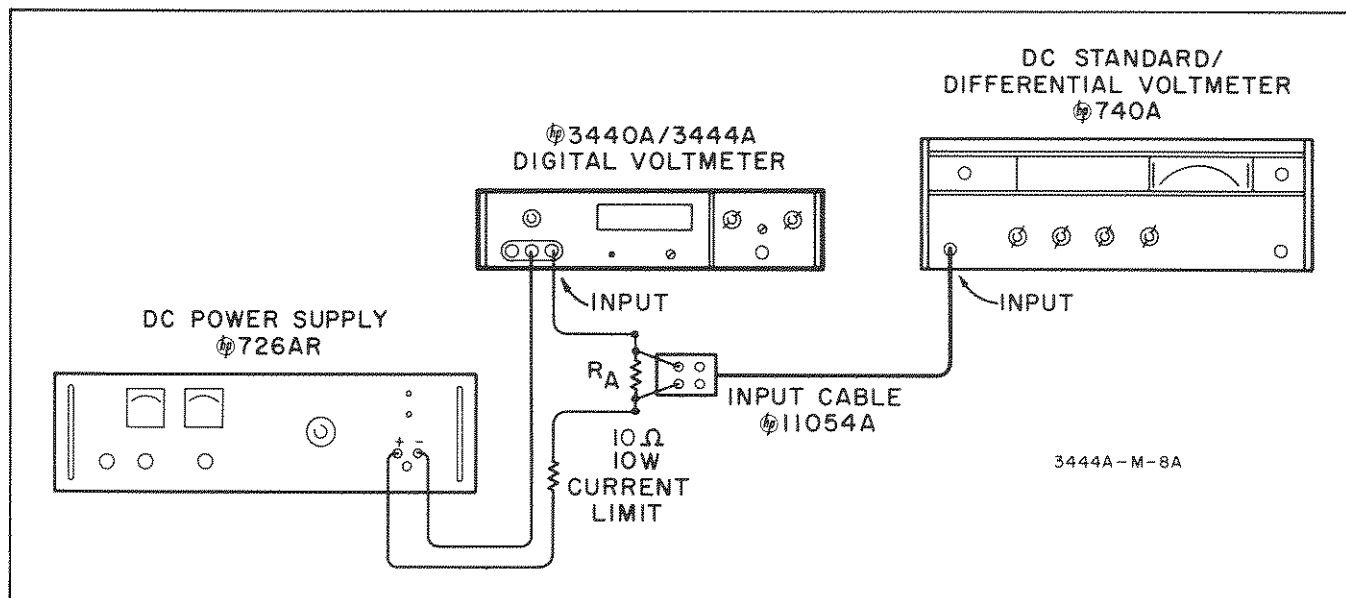


Figure 5-1. Ammeter Performance Check Setup

Table 5-4. Ammeter Performance Checks

3444A RANGE Selector	Precision Resistance Required (0.02% or better)	Differential Voltmeter Reading	Tolerance of 3440A Indication (+15°C to +40°C)
100 μ A	10 K Ω	1 V	99.79 to 00.21* μ A
1000 μ A	10 K Ω	10 V	997.9 to 002.1* μ A
10 MA	10 K Ω	50 V	4.989 to 5.101 MA
100 MA	10 Ω	1 V	99.79 to 00.21* MA
1000 MA	0.1 Ω	0.1 V	997.9 to 002.1* MA

- c. Repeat step b for each of the other ammeter scales using the voltages and resistances given in Table 5-4. If the tolerances listed are not met, refer to Paragraph 5-45.

CAUTION

For high current ranges, do not take readings until the reading on the 740A has become stable. This is due to the resistance change of the current limiting resistors caused by heating. Minimize the effects of contact resistance on RA.

5-21. DIGITAL RECORDER OUTPUT AND RESPONSE TIME CHECKS.

NOTE

This procedure is written for a 562A, 3440A, and 3444A with a 1-2-2-4 BCD code.

- 5-22. This performance check requires the use of a digital recorder, a voltage standard and a dc current supply (see Table 5-1).

5-23. TEST SETUP.

- d. This completes the ammeter calibration checks. Disconnect the setup of Figure 5-1 retaining the Differential Voltmeter for the next performance check.

- a. Connect the test setup shown in Figure 5-2, Digital Recorder Output Performance Check Setup.

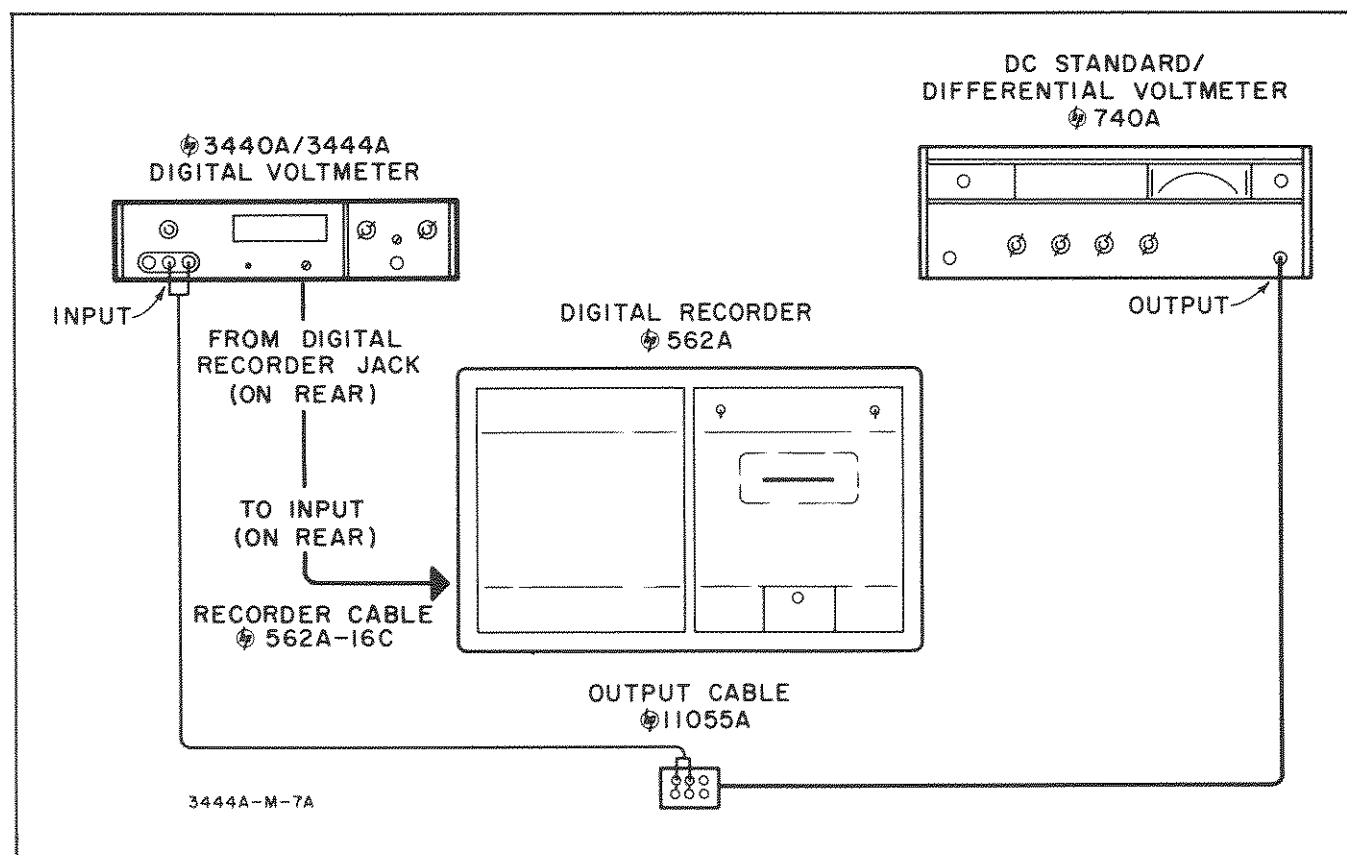


Figure 5-2. Digital Recorder Output Performance Check Setup

Paragraphs 5-24 to 5-27 and Tables 5-5 to 5-7

5-24. TEST PROCEDURE.

- a. Place the FUNCTION switch to the VOLTS position. Place the RANGE switch and the standard to the positions in Table 5-5, and check for proper recorder printout. (Set sample rate to 5/sec.)

Table 5-5. Digital Recorder Voltage Check

3444A RANGE	Adjust the Standard for Readout on the 3440A of:	RECORDER PRINTOUT
1000 MV	-200.0 mv	120004
100 MV	02.00 (-102 mv*)	902005
100 MV	-20.00 mv	120005
1000 MV	+200.0 mv	020004
100 MV	+20.00 mv	020005

* OVERRANGE lighted.

- b. Leaving the DC Standard at 20 mv output and the 3444A on the 100 mv range, check response time in the volts function. Turn the DC Standard output switch to the off position while operating the recorder. Push DC Standard output switch on, and the recorder should go from zero's to 99.95% of full readout in not more than six recordings or in 1 second.
- c. Remove the voltage standard input from the Model 3440A. Place the FUNCTION switch to OHMS and connect the resistors listed in Table 5-6 across the input terminals. The readout on the 3440A and the printout on the recorder should be the same except for the first and last digits of the recorder.
- d. Check the response time in the OHMS function by placing the 1 megohm resistor across the input terminals in the 10 M Ω range. Place the FUNCTION switch to VOLTS position and start the recorder operating. Recorder should record voltage readout. Change FUNCTION switch to OHMS. Recorder should print out 99.95% of full readout within 5 seconds.

Table 5-6. Digital Recorder Ohms Check

RESISTOR	3444A RANGE	3440A READOUT (See NOTE)	DIGITAL RECORDER PRINTOUT (See NOTE)
1000 Ω	1000 Ω	xxx. x	5xxxx4
1000 Ω	10 K Ω	x. xxx	5xxxx3
1000 Ω	100 K Ω	xx. xx	5xxxx2
1 M Ω	1000 K Ω	xxx. x	5xxxx1
9 M Ω	10 M Ω	x. xxx	5xxxx0
open	10 M Ω	x. xxx*	9xxxx0

NOTE: x Printout on recorder should be the same as corresponding x on 3440A readout.

* OVERRANGE lighted. Center 4 digits are unstable.

- e. Connect the circuit of Figure 5-1 leaving the digital recorder connected to the 3440A. The differential voltmeter need not be connected.
- f. Set the FUNCTION switch to AMPS position and connect the resistors of Table 5-7 in the place of R_A of the test setup. Adjust the power source for the readout on the 3440A listed. The recorder printout should be as listed.
- g. Check the response time in the amps function by having the test setup as indicated for the 100 μ A step in Table 5-7. Place a short across the 3440A input terminals. Remove the short. The recorder should be within 99.95% of its final value in not more than 6 recordings or within 1 second.
- h. This completes the digital recorder and response time performance checks. If satisfactory recorder operation is not obtained, refer to Paragraph 5-57. (Disconnect the digital recorder.)

Table 5-7. Digital Recorder Amps Check

R_1	3444A RANGE	3440A Readout	DIGITAL RECORDER PRINTOUT
0 Ω	1000 MA	+100.0	210001
0 Ω	1000 MA	-100.0	310001
0 Ω	100 MA	+10.00	210002
10 K Ω	10 MA	1.000	210003
10 K Ω	1000 μ A	100.0	210004
10 K Ω	100 μ A	00.00*	900005

*OVERRANGE lighted.

5-25. INPUT IMPEDANCE CHECK.

5-26. TEST SETUP FOR VOLTMETER INPUT IMPEDANCE.

- a. A 1 megohm $\pm 1\%$, 1/2 watt, fixed carbon film resistor is required for this check. Connect the test equipment according to Figure 5-3.

5-27. TEST PROCEDURE.

- a. Set the voltage standard to +10.00 volts.
- b. Place the RANGE selector in the 10 V position.

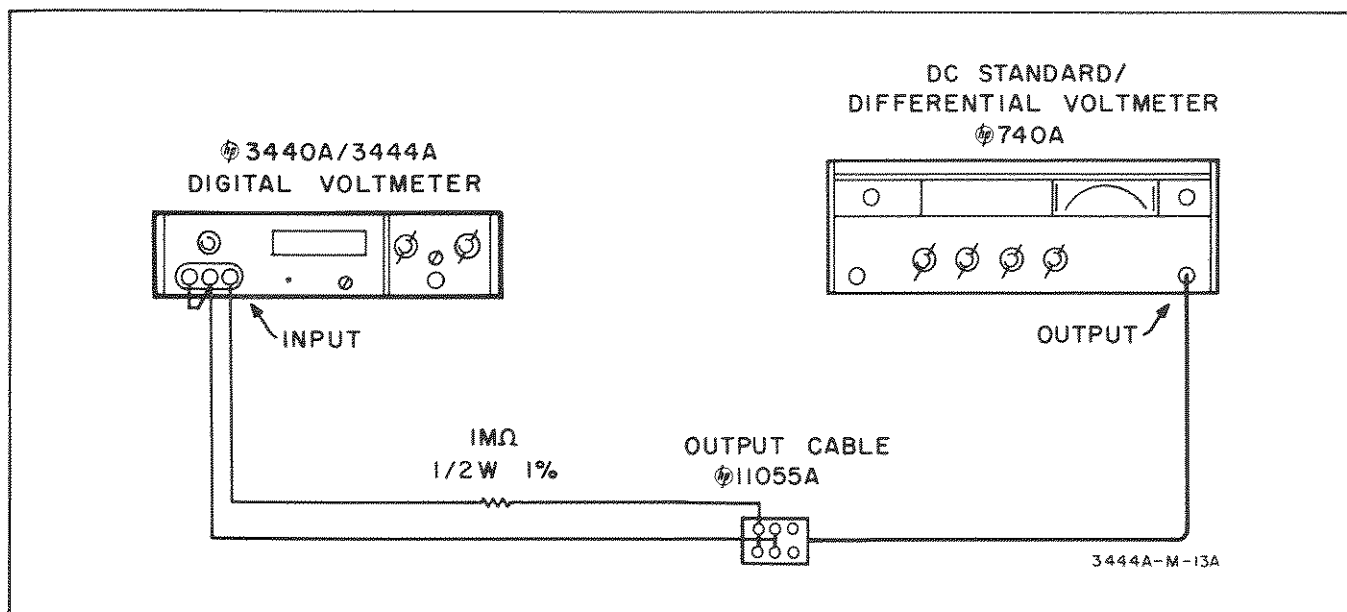


Figure 5-3. Voltmeter Input Impedance Performance Check Setup

- c. An indication should be obtained between 9.090 and 9.122 volts.

NOTE

This corresponds to an input resistance of 10.0 to 10.4 megohms where:

$$R_{\text{input}} = \frac{E_{3440A}}{10.0 - E_{3440A}} \times 1.0 \times 10^6 \text{ ohms}$$

as shown in Figure 5-4. Connect a jumper between High (red) and Common (⏏) INPUT terminals.

- b. Set SAMPLE RATE control fully counterclockwise (but not LINE OFF).
c. Set DC Standard controls as follows:

5-28. COMMON MODE REJECTION CHECK.

5-29. COMMON MODE REJECTION (VOLTMETER).

- a. Connect DC Standard between Model 3440A Common (⏏) and chassis (⏏) INPUT terminals

FUNCTION.	STD
RANGE.	1000 V
VOLTAGE SET	5000 (500 V)
OUTPUT.	ON

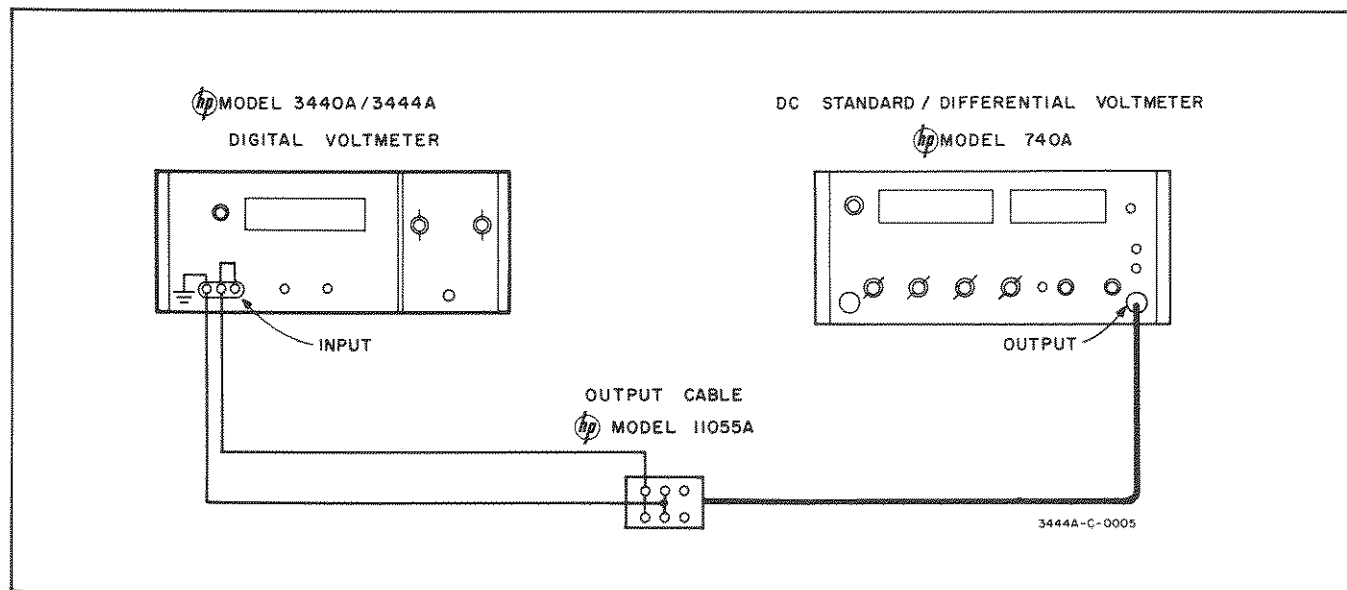


Figure 5-4. Voltmeter DC Common Mode Rejection Test Setup

- d. Absolute value of Model 3440A readout should be less than 0015 on all ranges.

NOTE

This corresponds to a Common Mode Rejection of 90 db on the 10 volt range where:

$$\text{Rejection} = 20 \log \frac{E_{in}}{E_{3440A}} \text{ db}$$

- e. Using Figure 5-4, replace the DC Standard with the Audio Oscillator. Leave the jumper between High (Red) and Common (⏏) INPUT terminals of the 3440A.

- f. Set Audio Oscillator controls as follows:

FREQUENCY. 60
FREQUENCY RANGE X1
AMPLITUDE and OUTPUT
ATTENUATOR 3.5 volts
rms (10 v
p-p)

- g. The readout on the 3440A should be not more than 0002 on the 10 v, 100 v, and 1000 v ranges.

NOTE

This corresponds to a Common Mode Rejection of 70 db on 10 volt range where:

$$\text{Rejection in db} = 20 \log \frac{E_{in} \text{ (rms)}}{E_{3440A} \text{ (pk)} \times 0.707}$$

- h. Connect the test setup shown in Figure 5-5 for the 100 and 1000 mv ranges on Common mode ac rejection.
- i. Adjust the DC Standard for a 3440A readout of 900 mv.

- j. Increase the amplitude of the 200CD to 3.5 v rms (10 v p-p).
- k. The readout on the 3440A should be between 899.0 and 901.0.
- m. Repeat steps i through k using the 100 mv range on the 3444A and a 90 mv readout on the 3440A.
- n. The readout on the 3440A should be between 89.90 and 90.10.

5-30. COMMON MODE REJECTION (AMMETER).

5-31. Connect the test setup in Figure 5-6 with the output of the DC Standard turned off at the output switch.

- a. Rotate the Model 3444A FUNCTION switch to the AMPS position and RANGE switch to 100 μ a position.
- b. Increase the voltage from the mercury cell, by adjusting the potentiometer, for a readout of 90.00 μ a on the 3440A.

- c. Adjust the DC Standard controls as follows:

FUNCTION. STD
RANGE. 1000 V
VOLTAGE SET 5000 (500 V)
OUTPUT. ON

- d. The readout on the Model 3440A should not change more than ± 21 counts.
- e. Turn the output switch on the DC Standard to the OFF position.
- f. Set the RANGE switch of the 3444A to the 1000 μ a position.
- g. Increase the voltage from the mercury cell, by adjusting the potentiometer, for a readout of 900.0 μ a.

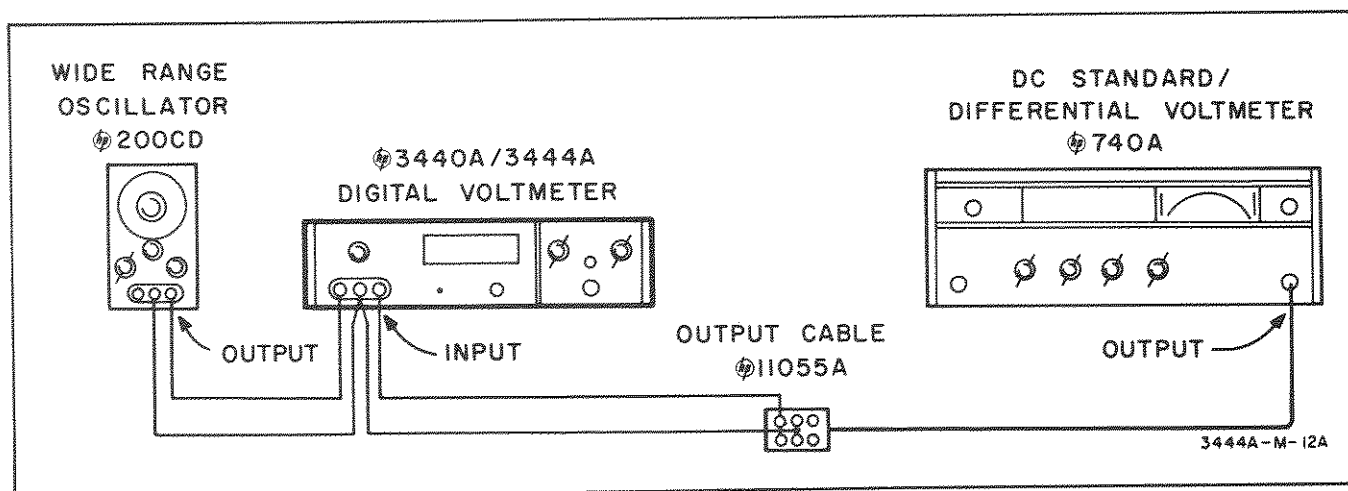


Figure 5-5. Millivolt 60 cps Common Mode Rejection Test Setup

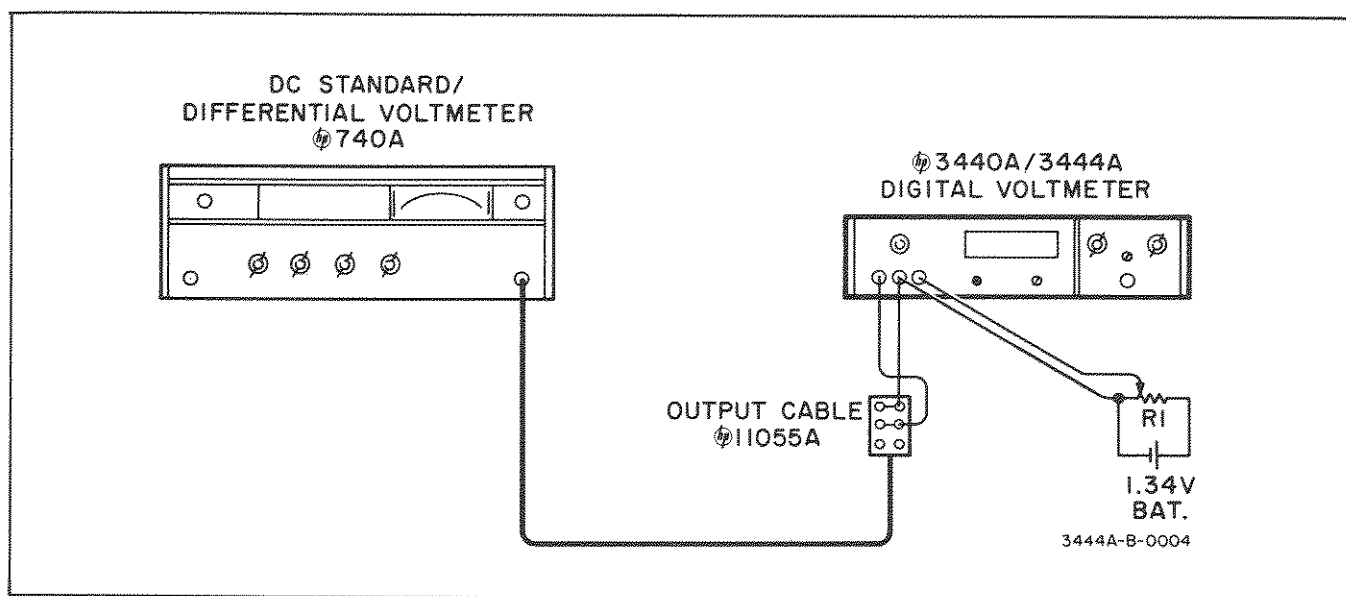


Figure 5-6. Ammeter Common Mode Rejection Test Setup.

- h. Turn the 740A OUTPUT switch to the ON position.
- i. The 3440A readout should change not more than ± 21 counts.
- j. Replace the 740A Standard in the test setup, Figure 5-6, with the Audio Oscillator. Set the frequency to 60 cycles and the amplitude to minimum.
- k. Repeat steps a and b.
- m. Adjust the amplitude of the Audio Oscillator to 3 volts p-p or 1.06 rms.
- n. The readout on the 3440A should change not more than 21 counts.
- o. Turn the oscillator output off and repeat steps f and g.
- p. Adjust the amplitude of the Audio Oscillator to 10 volts p-p (3.5 volts rms).
- q. The readout on the 3440A should change not more than ± 21 counts.

5-32. COMMON MODE REJECTION (OHMMETER).

- a. Connect the test setup in Figure 5-6 with the output of the DC Standard turned off and substituting a resistor across the input terminals of the 3440A in place of the battery and potentiometer.
- b. Use the resistors and ranges in Table 5-8. Turn on the DC Standard output switch applying 500 v between common and chassis ground (3440A). The readout should be within the tolerances listed in the table. Connect the Audio Oscillator output between common and chassis ground and set to 60 cycles ten volt output p-p (3.5 volts rms). The readout should also be within the tolerances listed in Table 5-8.

5-33. INPUT FILTER AC REJECTION CHECK.

5-34. VOLTAGE AC REJECTION CHECK.

- a. Using the test setup in Figure 5-7, connect the DC Standard and the Wide Range Oscillator in series with each other and connect to the input of the 3440A/3444A.
- b. Disconnect the ground strap on the Wide Range Oscillator and turn the amplitude to minimum (all instruments must have floating grounds).
- c. Set the Model 3444A controls as follows:

FUNCTION.	VOLTS
RANGE.	100 MV
- d. Set the DC Standard controls as follows:

FUNCTION.	STD
RANGE.	1 V
VOLTAGE SET	0900 (90 MV)
OUTPUT SWITCH . . .	ON
- e. The readout on the 3440A should be between 8990 and 9010.
- f. Adjust the frequency of the Wide Range Oscillator to 60 cycles and the output to 50 mv p-p. (Using the AC Voltmeter to measure this voltage, adjust the amplitude to 18 mv rms.)

Table 5-8. Ohmmeter Common Mode Rejection

Resistor	Range	Tolerance of 3440A Readout with 500 vdc or 3.5 vac
10 K Ω	10 K Ω	9.969 to 0.031* K Ω
100 K Ω	100 K Ω	99.69 to 00.31* K Ω
1000 Ω	1000 Ω	996.9 to 003.1* Ω
1 M Ω	1000 K Ω	996.9 to 003.1* K Ω
9 M Ω	10 M Ω	8.909 to 9.091 M Ω

*Indicates OVERRANGE lighted.

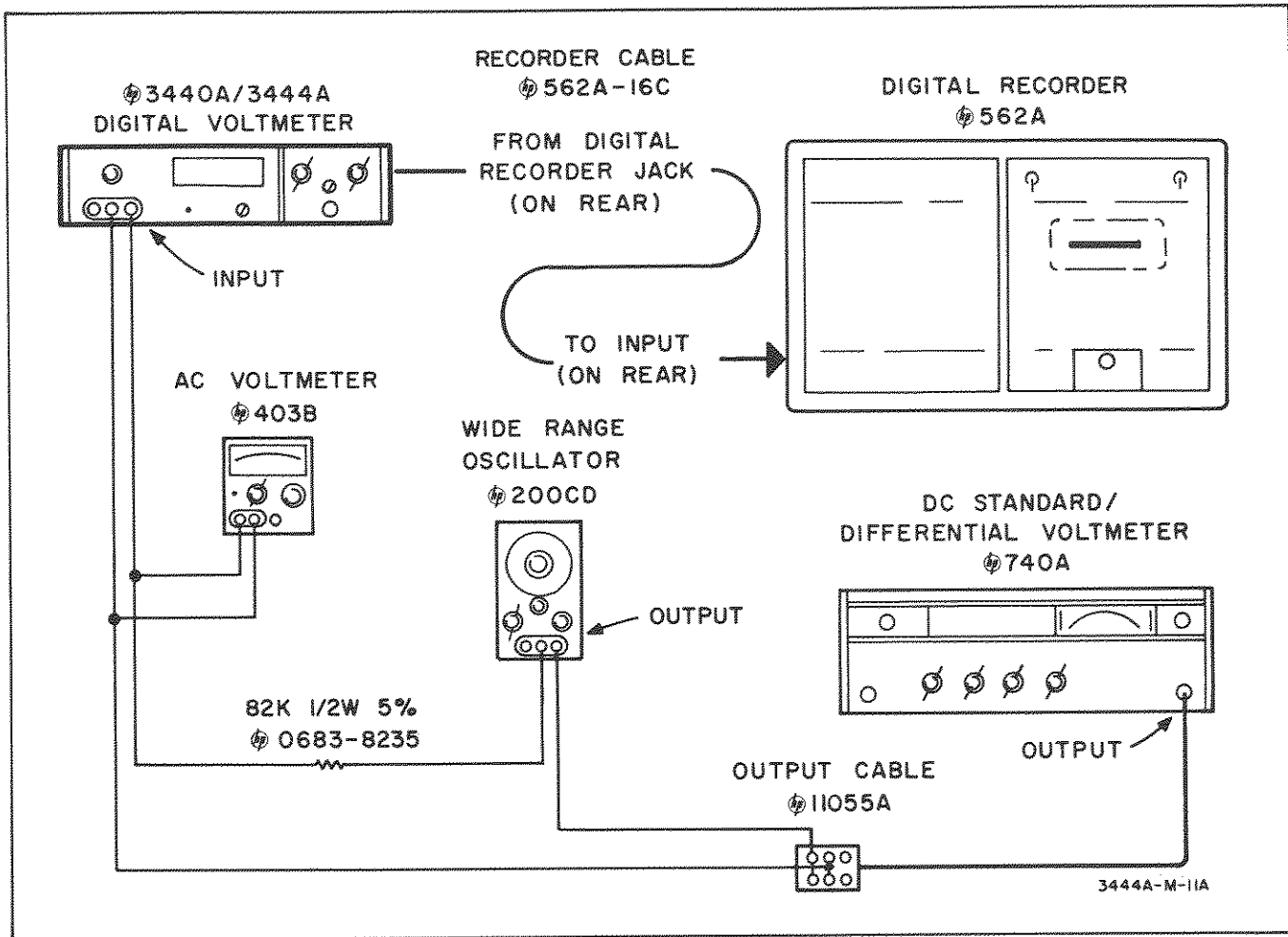


Figure 5-7. Input Filter AC Rejection Test Setup

- g. The center four digits on the recorder should still be between 8990 and 9010.
- h. Repeat steps b through f using the 1000 mv range on the 3444A, 900 mv from the 740A and 180 mv from the oscillator.
- i. The center four digits on the recorder should be between 8990 and 9010.

5-35. CURRENT AC REJECTION CHECK.

- a. Use the same test setup shown in Figure 5-7 except the clip-on AC Current Probe is added to monitor the ac current from the Wide Range Oscillator. This probe is inserted into the input terminals of the AC Voltmeter and clipped onto the lead connected to the + input terminal of the 3440A.
- b. With the output of the DC Standard and the Wide Range Oscillator turned off, set the 3444A controls as follows:

FUNCTION.	AMPS
RANGE.	1000 μ A
- c. Increase the DC Standard voltage output for a readout of 80.0 μ A on the 3444A.
- d. Increase the amplitude of the Wide Range Oscillator until a reading of 170 μ V is read on the

AC Voltmeter (the 456A Current Probe transfers ma to mv).

- e. The center four digits of the recorder should be between 7983 and 8017. If this range is within specifications, the other ranges should also be within specifications.

5-36. OHMMETER CURRENT CHECK.

NOTE

If the ohmmeter ranges are within specification, this check need not be made. The purpose of this check is only to aid in locating malfunctions.

5-37. The ohmmeter current check requires a DC Micro-Ammeter in addition to the Models 3440A/3444A Digital Multi-Function Meter. Set the DC Voltmeter-Ammeter to the current position and 3444A to the OHMS position. Connect the DC Voltmeter current and common probes to the input of the 3440A. Using the ranges given in Table 5-9, check to see if the ohmmeter current is within tolerance. (The ohmmeter current is a constant current for each range; therefore, the resistance of the DC Voltmeter has no effect on the current reading.)

5-38. This concludes the performance checks.

Table 5-9. Ohmmeter Current Check

Micro-Ammeter RANGE	3444A Ohms Range	Ohmmeter Current Reading Accuracy $\pm 10\%$
3 MA	1 K Ω	0.9 to 1.1 ma
0.003 MA	10 K Ω	90 to 110 μ a
0.003 MA	100 K Ω	9 to 11 μ a
1 μ A	1 M Ω	0.9 to 1.1 μ a
0.3 μ A	10 M Ω	0.09 to 0.11 μ a

5-39. ADJUSTMENT AND CALIBRATION PROCEDURE.

5-40. The following procedures constitute a complete adjustment and calibration procedure that should be performed when it has been determined by the performance checks that the Model 3444A is out of adjustment.

NOTE

The calibration procedure for the 10, 100, and 1000 v ranges is in Section V of the 3440A Operating and Service Manual. Indiscriminate adjustment of the internal controls to "refine" settings should not be attempted as this may actually cause trouble. Individual calibration procedures may be utilized, however, to correct deficiencies covering only one type of operation of the instrument. For instance, only the ammeter adjustment and calibration procedures need be utilized if it is discovered that only the ammeter operation of the instrument is out of tolerance. If the millivolt adjustments are made, the ammeter and ohmmeter ranges should be rechecked. If difficulty is encountered in accomplishing any of the adjustments, refer to the referenced section of the troubleshooting procedures.

5-41. VOLTMETER ADJUSTMENT AND CALIBRATION.

5-42. The voltmeter adjustment and calibration procedures should be accomplished whenever the performance checks indicate that the 100 mv or 1000 mv scales of the 3444A are not within tolerance, or whenever it is determined that the overall operation of the instrument appears to have deteriorated from the specified tolerances. If an adjustment is made on the 100 mv or the 1000 mv ranges, recheck the ohms and amps performance and adjust if necessary. Figure 5-10, Adjustment and Calibration Test Points and Controls, illustrates the locations of the test points and calibration controls necessary for these procedures.

- Set voltage standard to zero. Short the input terminals of 3440A. Place RANGE switch in 100 MV position. Adjust front panel ZERO control for 00.00 indication.

- Place RANGE selector in 1000 MV position. Adjust A2R31 (Figure 5-3) to obtain a zero reading on the 3440A. Remove short from input terminals.
- Set voltage standard to +800 mv. Adjust A2R36 (Figure 5-10) for a reading of +800.0 mv.
- Set voltage standard to -800 mv. If the negative reading is not -800.0 mv, then readjust A2R36 for best compromise (split errors). The positive reading should be at or between +799.1 mv and +800.9 mv. The negative reading should be at or between -799.1 mv and -800.9 mv. If these values cannot be obtained, refer to Amplifier Checks and Adjustment, Paragraph 5-46, and to symptom g, Table 5-10.
- Adjust voltage standard to +80.00 mv. Adjust A2R34 (Figure 5-10) for a reading of +80.00 mv. Set the voltage standard to -80.00 mv. If the indication obtained is not -80.00, readjust A2R34 for best compromise.

NOTE

If these values cannot be obtained, refer to Amplifier Checks and Adjustment, Paragraph 5-46, and symptom g, Table 5-10.

- This completes the voltmeter adjustment and calibration procedures. Remove the voltage standard input leads to the 3440A.

5-43. OHMMETER ADJUSTMENT AND CALIBRATION.

5-44. The ohmmeter adjustment and calibration procedures should be accomplished in their entirety whenever the performance checks indicate that any of the ohmmeter ranges are not operating within their stated tolerances. Figure 5-10, Adjustment and Calibration Test Points and Controls, illustrates the locations of the test points and calibration controls necessary for these procedures.

- The 3440A/3444A should be operating for at least 1/2 hour before this adjustment is made.
- Place the FUNCTION selector in the VOLTS position and the RANGE selector in the 100 MV position. Adjust the front panel ZERO control for 00.00 indication, if necessary.
- Press INT. CHECK button on 3440A and adjust for 8000 indication, if necessary.
- Place the FUNCTION selector in the OHMS position and the RANGE selector in the 10 K Ω position.
- Place a 10 K high-precision resistor across the INPUT terminals of the 3440A.

- f. Adjust A3R18 (Figure 5-10) for an indication of overrange 0.000. Remove the 10 K Ω precision resistor. If A3R18 is not sufficient to bring the readout to 0.000, perform the following.

- (1) Rotate the RANGE selector to the 100 v position. Connect a lead from A3TP1 to the 3440A + INPUT terminal. A reading of approximately -20 volts should be obtained. Adjust voltage by removing jumpers or adding jumpers across A3R12, A3R13, or A3R14 until voltage can be adjusted above and below -20 volts by turning A3R18. Clipping R14 jumper will change the voltage the most, and R12 jumper will change the voltage the least. Repeat steps e and f.
- (2) Rotate the RANGE selector to the 10 M Ω position.
- (3) Place a 9 M Ω resistor across the INPUT terminals of the 3440A (7 M Ω to 10 M Ω may be used).
- (4) Adjust A3R7 for an indication of 9.000. Remove the 9 M Ω precision resistor.

- g. Ohmmeter tracking may be checked by performing the ohmmeter calibration accuracy checks of Paragraph 5-13.
- h. If specifications cannot be met, refer to Figure 5-11, Resistance Ranges, and Paragraph 5-56.
- i. This completes the ohmmeter adjustment and calibration procedures.

5-45. AMMETER ADJUSTMENT AND CALIBRATION.

- a. Connect the test setup shown in Figure 5-1, Ammeter Calibration Check Setup, and allow instrument to warm up for 1/2 hour.
- b. Place FUNCTION selector in the VOLTS position and the RANGE selector in the 100 MV position. Observe that an indication of ± 00.00 ± 0.01 is still obtained. If not, adjust front panel ZERO control to obtain ± 00.00 .
- c. Place the FUNCTION selector in the AMPS position and the RANGE selector in the 100 MA position. Use a 10 Ω high-precision resistor in the circuit of Figure 5-1 and set the DC Power Supply to obtain 1 volt as read on the Differential Voltmeter.
- d. Adjust A3R26 (Figure 5-10) to obtain an over-range indication of +00.00. Check that A3R26 setting is at least 5 counts away from the high limit of pot travel.
- e. Remove the 10 Ω high-precision resistor from the circuit and replace it with an 0.1 Ω high-precision resistor. Place the RANGE selector in the 1000 MA position and adjust the DC Power Supply to obtain 0.1 volts as read on the Differential Voltmeter.

- f. Adjust A3R27 (Figure 5-10) to obtain an indication of +000.0.
- g. This completes the ammeter adjustment and calibration procedures.

5-46. AMPLIFIER CHECKS AND ADJUSTMENT.

- a. Use the test setup as given in Paragraph 5-11. Adjust the ac line voltage to a nominal 115 v/230 v.
- b. Rotate the FUNCTION selector switch to the VOLTS position and the RANGE switch to the 100 MV position. Set the DC Standard to zero. Measure (using Φ Model 412A or equivalent) the dc voltage at test point A2TP1 (see Figure 5-10). The voltage measured should be between -35 and -50 volts. If not, refer to symptom a, Table 5-10.
- c. Repeat step b with the RANGE switch in the 1000 MV position. The voltage measured would be between -35 and -50 volts. If not, refer to symptom a, Table 5-10.
- d. Measure the ac voltage at test point A2TP1 on 1000 mv range. The ac voltage measured should be between 0.02 and 0.15 volts. If not, refer to symptoms b and c, Table 5-10 and Figures 5-8 and 5-9.
- e. Repeat step d with the RANGE switch in the 100 MV position. The ac voltage measured should be between 0.1 and 1.0 volts. If not, refer to symptoms b and c, Table 5-10.

5-47. RELAXATION OSCILLATOR.

- a. Set controls of the electronic counter (Φ Model 522B or equivalent) as follows: FUNCTION SELECTOR to FREQUENCY, and STD GATE TIME to 1 sec. Connect the INPUT to test point A2TP1 (Figure 5-10).
- b. With the RANGE switch on 100 MV, adjust the voltage standard to 1 volt. This will heavily overdrive the amplifier.
- c. Adjust A2R9 so that the counter reading is 200 ± 1 cps. If unable to do so, refer to symptom d, Table 5-10.
- d. Set the voltage standard to zero volts. Remove the counter lead from A2TP1.

5-48. 100 MV RANGE NOISE.

- a. Observe the 3440A indication for a period of about 15 seconds. Reading from left to right, the first two digits should be zero. The third digit should be zero or one. The fourth digit will probably flicker but should assume only two successive values. If a third value shows only occasionally, adjust the front panel ZERO control and rerun the test. If the last digit flickers between 9 and 0, then the third digit will correctly flicker between 1 and 0.

5-49. LOOP GAIN TEST.

- a. Place the RANGE switch in the 1000 MV position. Properly check the zero reading on the 3440A. Adjust A2R31 if necessary.
- b. Remove the shorting plug across test points A2TP2 and A2TP3. Connect a 5 volt dc source across the two test points (polarity unimportant). Note the indication obtained. Remove the 5 volt source. The indication should change by 1, 2, or 3 counts. Compute loop gain according to the following formula:

$$\text{Loop Gain} = \frac{5000}{\text{indicated change of counts}}$$

The loop gain must be at least 2000. Replace the shorting plug. If satisfactory gain is not obtained, refer to symptom f, Table 5-10.

5-50. ETCHED CIRCUIT BOARDS.

5-51. When replacing a component on the plated-through type of etched circuit board, the component can be soldered from either side of the board.

- a. Avoid applying excessive heat when soldering on the circuit board. Suggested iron and tip size are given in Table 5-1.
- b. To remove a damaged component, clip the component lead near the component. Then apply heat and remove the lead with a straight upward motion.
- c. Use a cup tip to remove components having multiple connections, such as potentiometers. Refer to Table 5-1 for iron and tip types.
- d. Use a toothpick to free eyelet of solder before installing a new component.

5-52. TROUBLESHOOTING PROCEDURE.

5-53. The following troubleshooting procedures should be used only after it has been determined that the difficulty is not a calibration or adjustment problem. This can be determined either by attempting the proper calibration procedures or by the nature of the difficulty. Specific troubleshooting procedures are given for Adjustment and Calibration Troubleshooting (Paragraph 5-55), Digital Recorder Output Troubleshooting (Paragraph 5-57), and for General Troubleshooting (Paragraph 5-59).

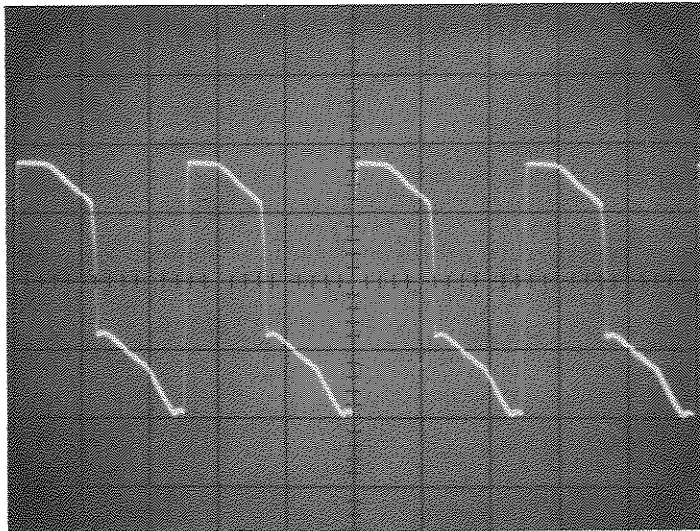
5-54. Prior to troubleshooting, inspect the test setup used, to determine that the source of trouble is not external to the 3444A or 3440A. Also, a dirty or contaminated 3444A rear panel connector can cause errors on the 100 mv range. Type TF Freon (Stock No. 8500-0232) is recommended for cleaning this connector.

5-55. ADJUSTMENT AND CALIBRATION TROUBLESHOOTING PROCEDURE.

5-56. When difficulties are encountered during the adjustment and calibration procedures, Table 5-10 (Adjustment and Calibration Troubleshooting Aids) should be consulted. Each symptom in Table 5-10 is keyed to a specific adjustment or calibration procedure and is referenced in the appropriate section of the adjustment and calibration procedures. Table 5-10 has been coordinated with the adjustment and calibration procedures to allow expedient repair; additional troubleshooting procedures are given in Paragraph 5-57, Digital Recorder Output Troubleshooting, and Paragraph 5-59, General Troubleshooting, to assist in troubleshooting situations not covered by Table 5-10.

Table 5-10. Adjustment and Calibration Troubleshooting Aids

Symptom	Possible Cause	Corrective Action
a. DC voltage at A2TP1 out of tolerance	A2CR3, A2Q1, A2Q2, A2Q3, A2Q4	Check A2CR3 for 82 $\pm$ 5 volts, then check transistors.
b. AC voltage at A2TP1 too high	Photocell A2V2 open	High ac voltage is due to amplifier oscillations. Temporarily place a 500 K Ω resistor across photocell. If oscillations stop, the photocell is faulty. Replace chopper assembly.
c. AC voltage at A2TP1 too low	Amplifier gain too low	Check loop gain of amplifier and wave shapes, Figures 5-8 and 5-9.
d. Unable to adjust chopper to 200 cps	A4C3	Change value of C3 if necessary.
e. Excessive noise on 100 mv RANGE	A2Q1 also A2C5, A2C9, zener A2CR3, photocell assembly	Replace A2Q1. If noise persists, check other components in order listed.
f. Low loop gain (high count shift)	Low amplifier gain (A2Q2, A2Q3, or A2Q4) or photocell assembly performance below normal	If noise is OK, replace A2Q2, A2Q3, or A2Q4 to raise gain; also check incremental gain from base of A2Q5 to collector of A2Q6 (should be about 36).
g. Negative calibration readings higher than positive readings	A2C9	Check for proper polarity and value; also recheck front panel ZERO.



a. Location = A2TP1

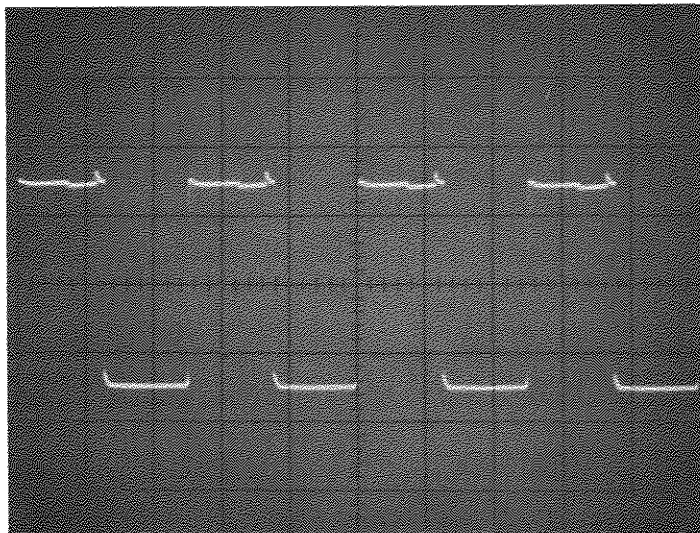
3444A RANGE = 1000 mv

Shorting plug removed from A2TP2 and
A2TP3

Input Voltage = +850 mv

Vertical Sensitivity = 20 volts/cm

Sweep = 2 ms/cm



b. Location = collector of A2Q3

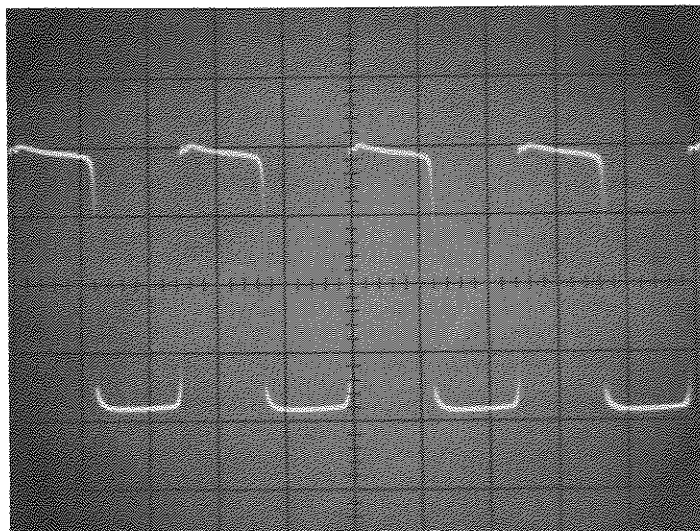
3444A RANGE = 1000 mv

Shorting plug removed from A2TP2 and
A2TP3

Input Voltage = +850 mv

Vertical Sensitivity = 1.0 volts/cm

Sweep = 2 ms/cm



c. Location = collector of A2Q2

3444A RANGE = 1000 mv

Shorting plug removed from A2TP2 and
A2TP3

Input Voltage = +850 mv

Vertical Sensitivity = 0.2 volt/cm

Sweep = 2 ms/cm

Figure 5-8. Typical Amplifier Waveforms

- a. Location = collector of A2Q1

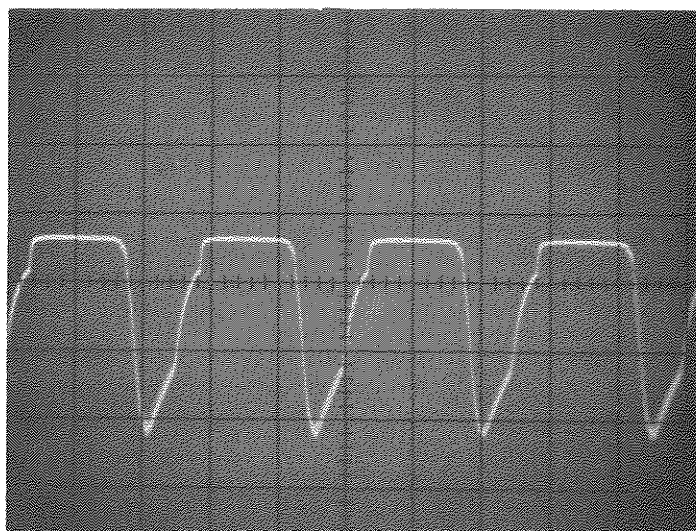
3444A RANGE = 1000 mv

Shorting plug removed from A2TP2 and
A2TP3

Input Voltage = +850 mv

Vertical Sensitivity = 0.1 volt/cm

Sweep = 2 ms/cm



- b. Location = base of A2Q1

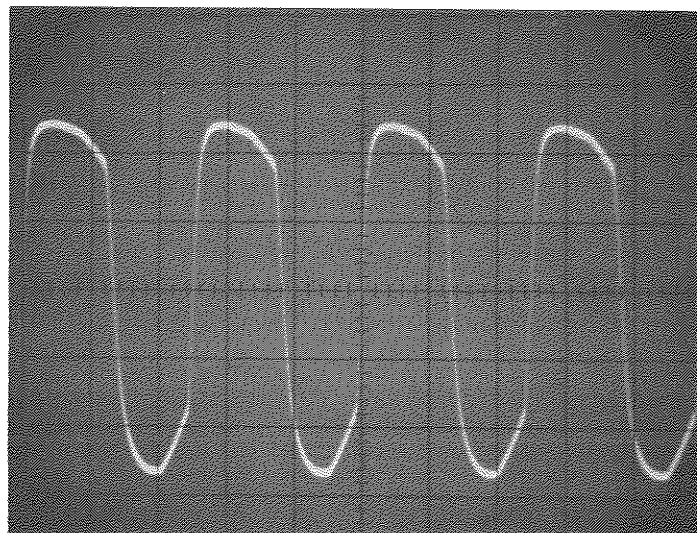
3444A RANGE = 1000 mv

Shorting plug removed from A2TP2 and
A2TP3

Input Voltage = +850 mv

Vertical Sensitivity = 0.1 volt/cm

Sweep = 2 ms/cm



- c. Location = collector of A2Q1

3444A RANGE = 100 mv

Shorting plug removed from A2TP2 and
A2TP3

Input Voltage = +85.00 mv

Vertical Sensitivity = 0.1 volt/cm

Sweep = 2 ms/cm

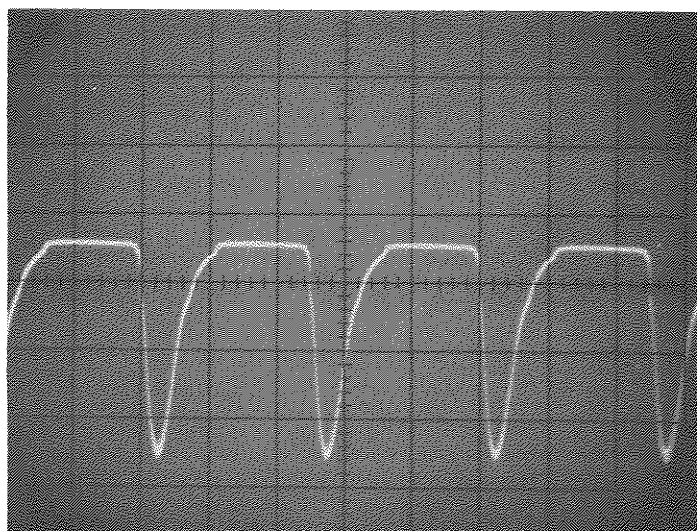


Figure 5-9. Typical Amplifier Waveforms

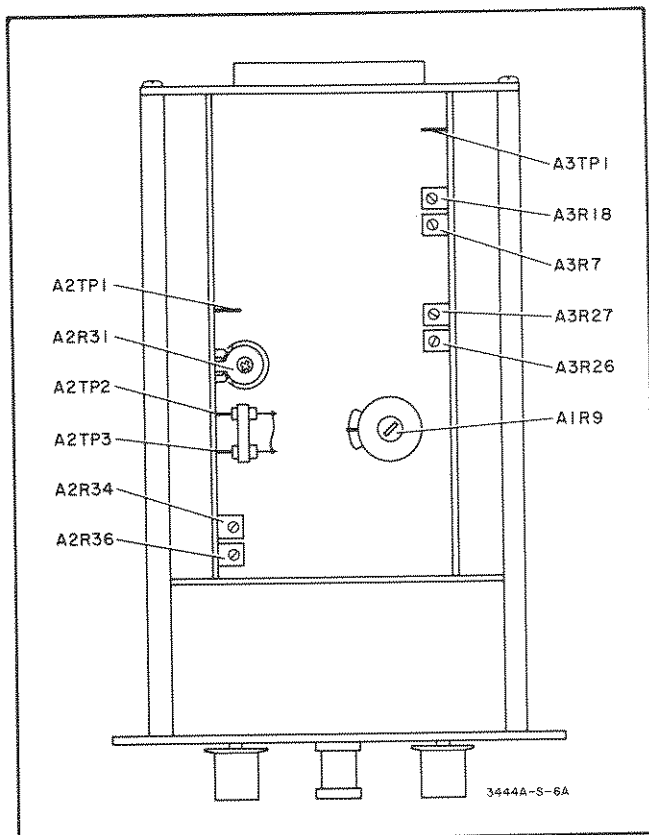


Figure 5-10. Adjustment Test Points and Control Location

5-57. DIGITAL RECORDER OUTPUT TROUBLESHOOTING.

5-58. Before conducting troubleshooting procedures involving the digital output circuits of the 3444A, ensure that all of the other circuits of the instrument are functioning properly. Also ensure that connector J2, on the back panel of the 3440A and the connectors on the back of the 3444A are not dirty or contaminated. If necessary, clean with type TF Freon (Stock No. 8500-0232).

- First determine, by using the performance checks or some other series of readings, which digital recorder columns are not functioning properly.
- If none of the digital recorder columns are recording correctly, refer to the Operating and Service Manual for the Digital Recorder.
- If only several, or one, of the columns is found to be consistently in error, refer to Figure 5-16, Model 3444A Function Range Schematic Diagram. Since the Digital Recorder outputs are electrical signals representing the measuring functions of the instrument, it is necessary to check only those electrical circuits associated with the malfunctioning columns. Figure 5-16 indicates which output pins are associated with the various columns of digital information. Usually, resistance measurements back from the proper pins will determine the faulty component. See Paragraph 5-50 before replacing components on printed circuit boards.

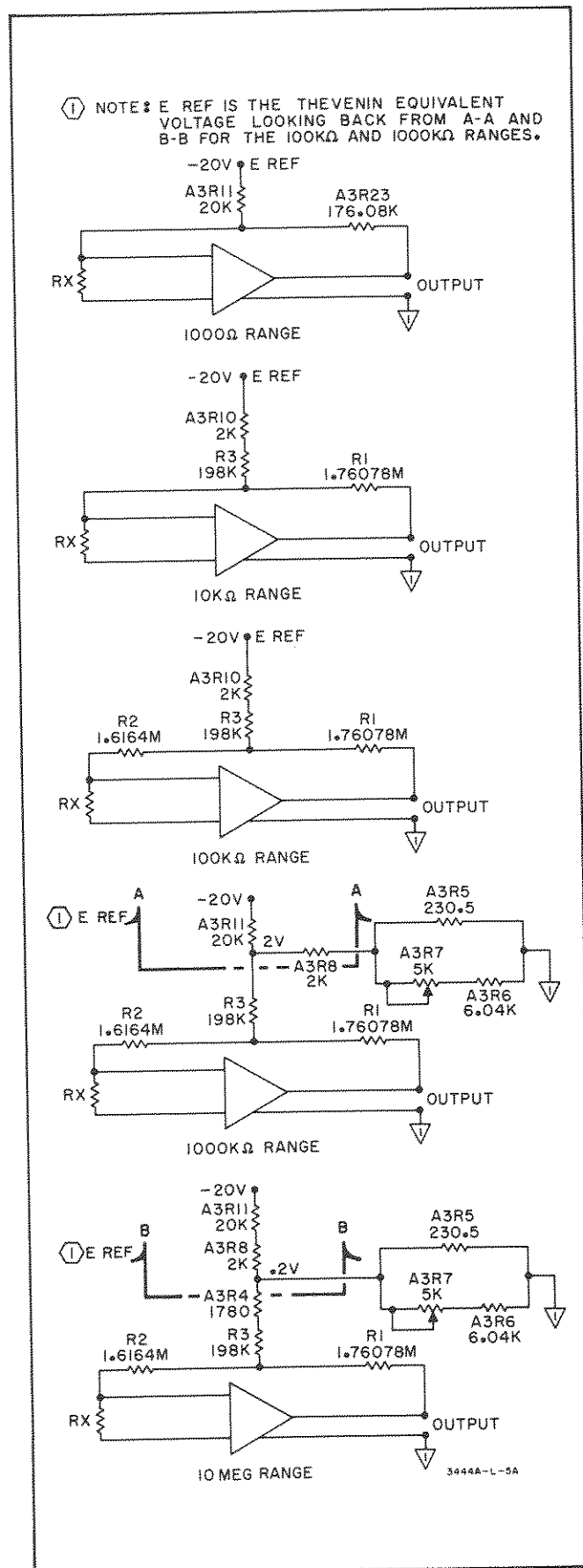
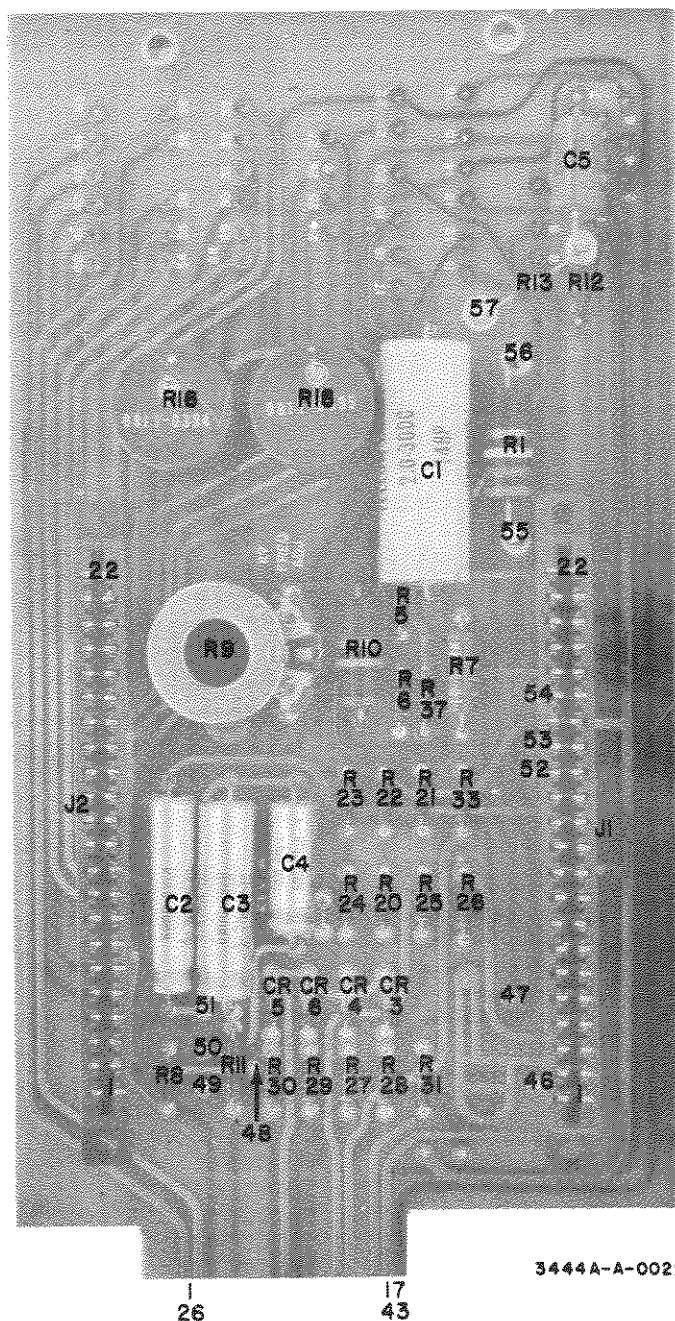


Figure 5-11. Circuits for Ohmmeter Ranges

5-59. GENERAL TROUBLESHOOTING.

5-60. General troubleshooting becomes necessary whenever problems are encountered which cannot be corrected or located through the use of the adjustment and calibration procedures and their associated troubleshooting procedures.

- a. The first objective is to determine exactly which functions of the instrument are faulty. This can be determined through the use of the performance checks or some similar type of checks. Often the use of a few, quick (not necessarily for accuracy) checks of the three functions will determine what circuits are malfunctioning.
- b. Using the information obtained in step a, refer to the block diagrams of the Voltmeter, Ohmmeter, and Ammeter circuits (Figures 4-2, 4-3, and 4-4) to determine which circuits are most likely at fault. Figures 5-12, 5-13, and 5-14 illustrate the location of parts on the printed circuit boards.
- c. Figure 4-1 (Amplifier Block Diagram) may be used for initial troubleshooting of the amplifier circuits.
- d. A schematic diagram of the entire instrument is shown in Figures 5-15 and 5-16.



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A1 is connected directly to the following pins of P6: 1, 2, 9, 13, 14, 16, 17, 26, 28, 30, 33, 34, 35, 36, 38, 41, 43.

- 1 -- to S2G-7
- 2 -- open (to S2G-1 for 1-2-4-8 code)
- 3 -- to S1F-6
- 4 -- open (to S1F-6 for 1-2-4-8 code)
- 5 -- to S2G-1
- 6 -- open (to S2G-7 for 1-2-4-8 code)
- 7 -- to S1E-4
- 8 -- to zero pot R4
- 9 -- to S1C-6
- 10 -- to S1C-5 and S1D-8
- 11 -- zero pot R4
- 12 -- to center of zero pot R4
- 13 -- to S1D-5
- 14 -- to S1F-5
- 15 -- to S1F-7
- 16 -- to S2R1
- 17 -- to S1F-4
- 18 -- to S1D-4
- 19 -- to S2G-4
- 20 -- to S2A-6
- 21 -- to S2R2
- 22 -- to S1F-8
- 24 -- to S2C-4
- 25 -- to S2E-9
- 26 -- to S2F-3
- 27 -- to S2E-10
- 28 -- to P6 pin 22
- 29 -- to S2E-8
- 30 -- to S2F-2
- 31 -- to S2C-3
- 32 -- to S2C-1
- 33 -- to S2F-6 and S2E-6
- 34 -- to S2B-3
- 35 -- to S2B-2
- 36 -- to S2F-4
- 38 -- to S2F-5 and S2E-5
- 39 -- to S1C-3
- 40 -- to S2B-4 and S2A2
- 41 -- to S2A-3
- 42 -- to S1D-7
- 43 -- to S2A-1
- 44 -- to S2H-5
- 45 -- to S1D-1
- 46 -- to C3
- 47 -- to A4V2
- 48 -- to ∇ of A4
- 49 -- } to A4
- 50 -- }
- 51 -- to junction of A4V3 and A4V4
- 52 -- to 14 of J1
- 53 -- to 15 of J1
- 54 -- to 17 of J1
- 55 -- to pin 25 of P6
- 56 -- to S2D-6
- 57 -- to S2D-1

Figure 5-12. A1 Location of Components

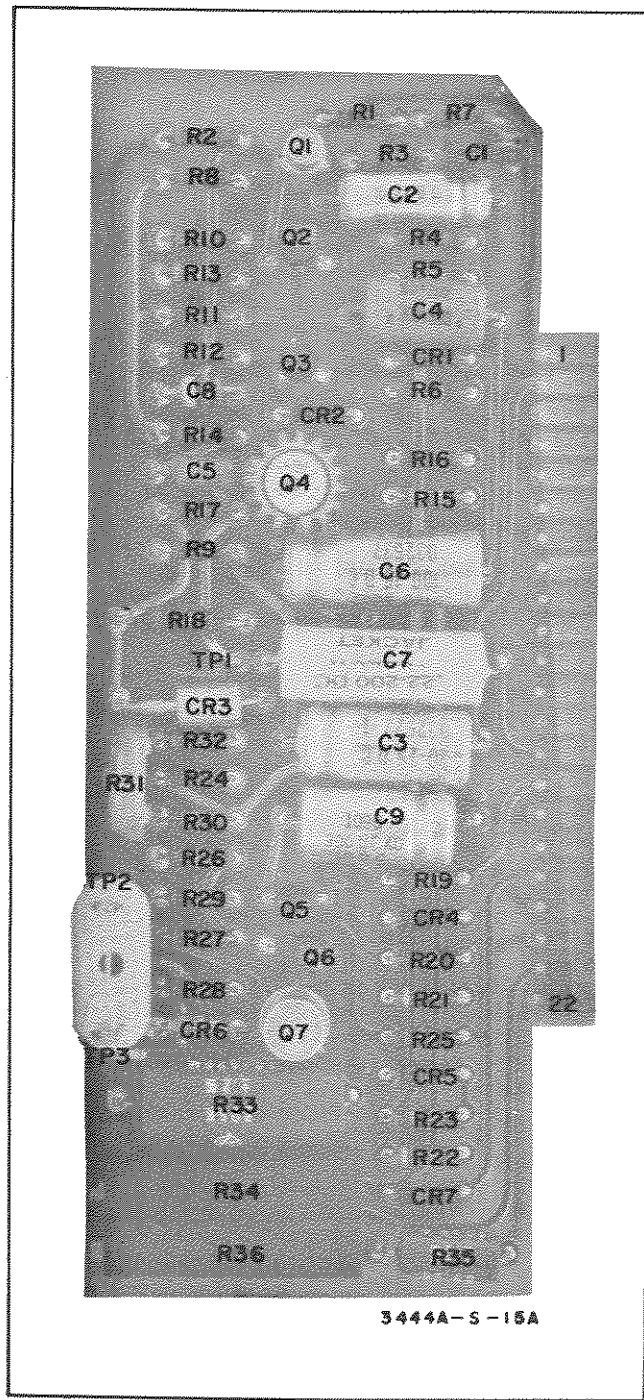


Figure 5-13. A2 Location of Components

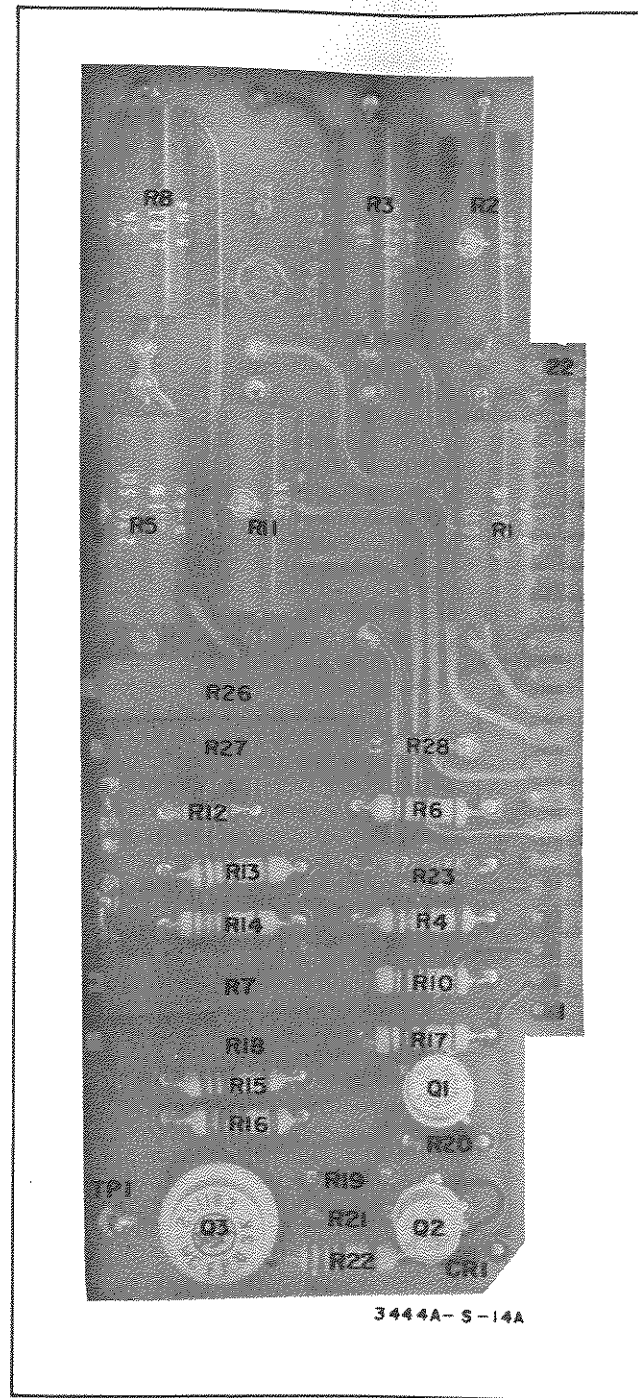


Figure 5-14. A3 Location of Components

- NOTES**
1. ALL RESISTORS IN OHMS AND CAPACITORS IN MICROFARADS UNLESS OTHERWISE DESIGNATED.
 2.  DESIGNATES FRONT PANEL LOCATION.
 3.  OUTLINES PART OF MODEL 3440A.
 4.  OUTLINES A1 AND A4 ASSEMBLIES.
 5.  OUTLINES A2 ASSEMBLY.
 6.  DENOTES FEEDBACK.
 7.  DENOTES SIGNAL PATH.
 8. REFERENCE DESIGNATORS WITHIN AN ASSEMBLY ARE COMPLETED BY PREFIXING THE ASSEMBLY DESIGNATOR (R12 IN A1 IS A1R12).
 9.  DESIGNATES SIGNAL GROUND (3440A).
 10.  DESIGNATES ATTENUATOR GROUND (3440A).
 11.  DESIGNATES SUBCIRCUIT GROUND JOINING  LATER.
 12. THE NUMBERS INSIDE ASSEMBLY BOUNDRIES ARE WIRE NUMBERS.
 13. RANGE SWITCH POSITIONS HAVE A RANGE FOR EACH FUNCTION, ONLY THE RANGES USED ARE SHOWN ON THIS SCHEMATIC. (WHERE ALL FUNCTION RANGES ARE USED, NONE ARE DESIGNATED.)

S2 RANGE			
POS.	VOLTS	OHMS	AMPS
1ST	100 MV	1000 Ω	100 μ A
2ND	1000 MV	10 K Ω	1000 μ A
3RD	10 V	100 K Ω	10 MA
4TH	100 V	1000 K Ω	100 MA
5TH	1000 V	10 M Ω	1000 MA

REFERENCE DESIGNATORS

CHASSIS	A1	A2	A4	P/O MODEL 3440A	P/O P6
S1		R1-R36	R1-R4	A1R1-A1R8	
S2	R1, R5-R13, R37	C1-C9	C1-C5	J1, P/O J5	J1
C3	C1-C5	Q1-Q7	DS1-DS3	A1C1	
R4		CR1-CR7	V1-V4		

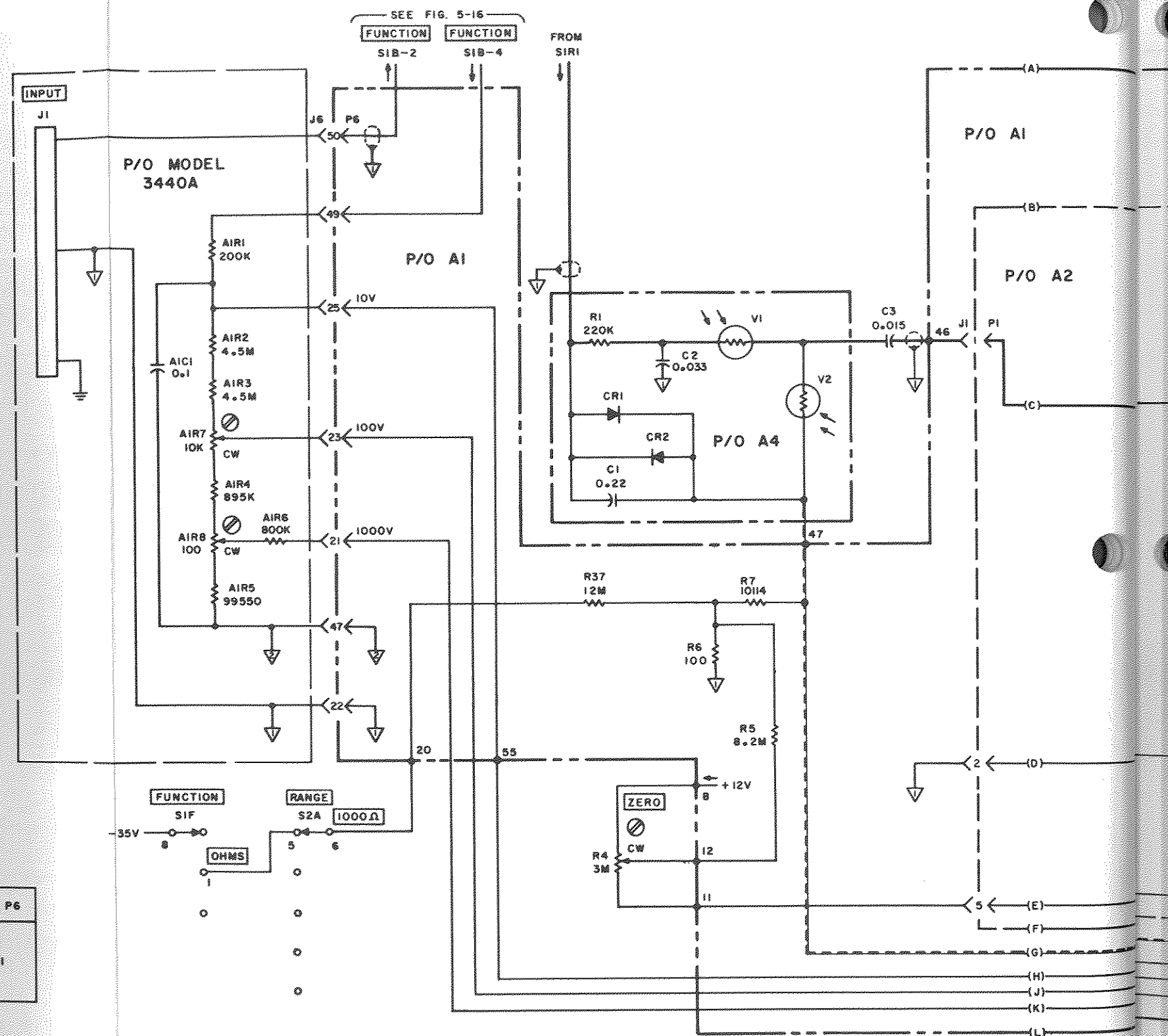
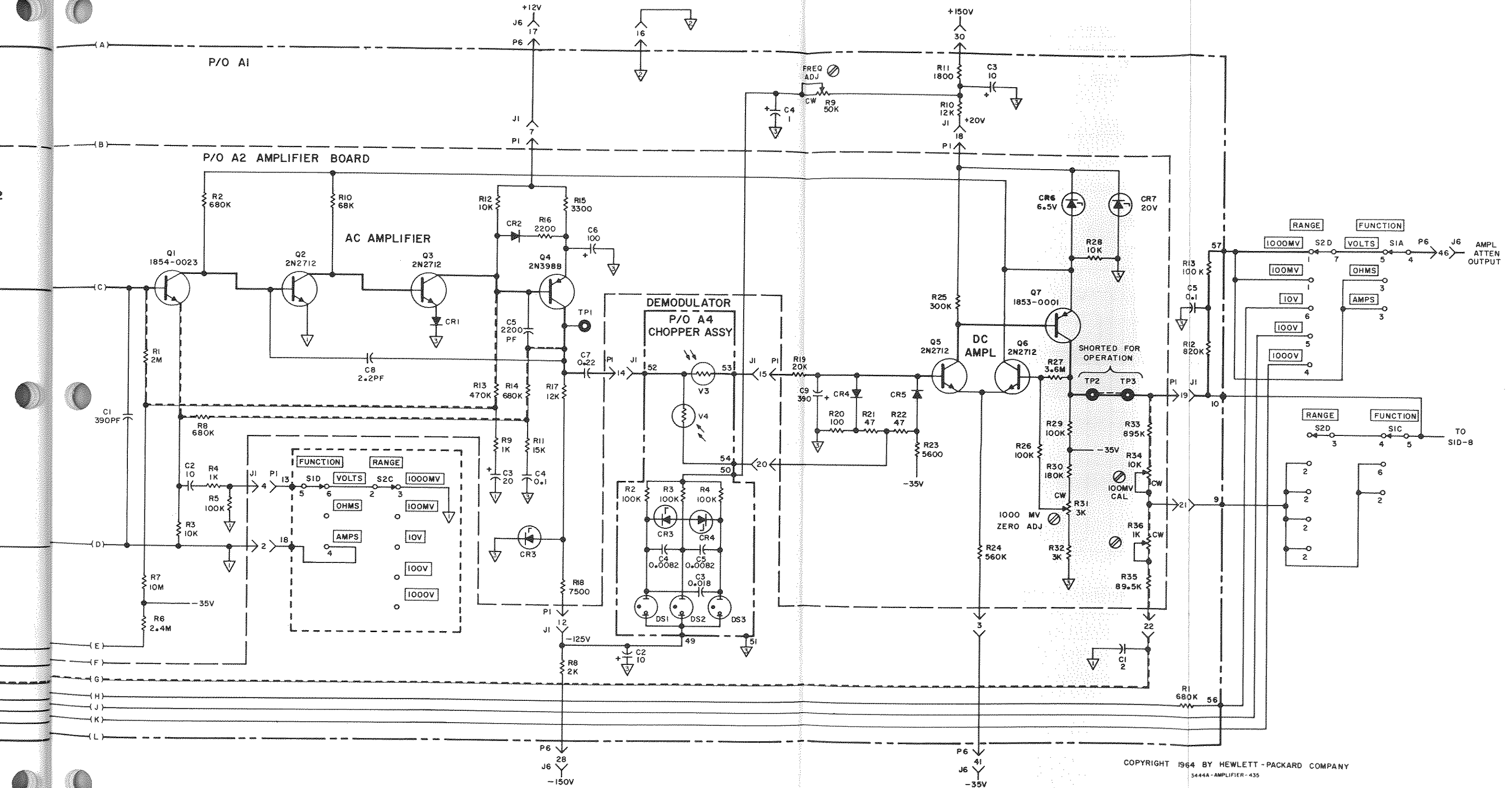
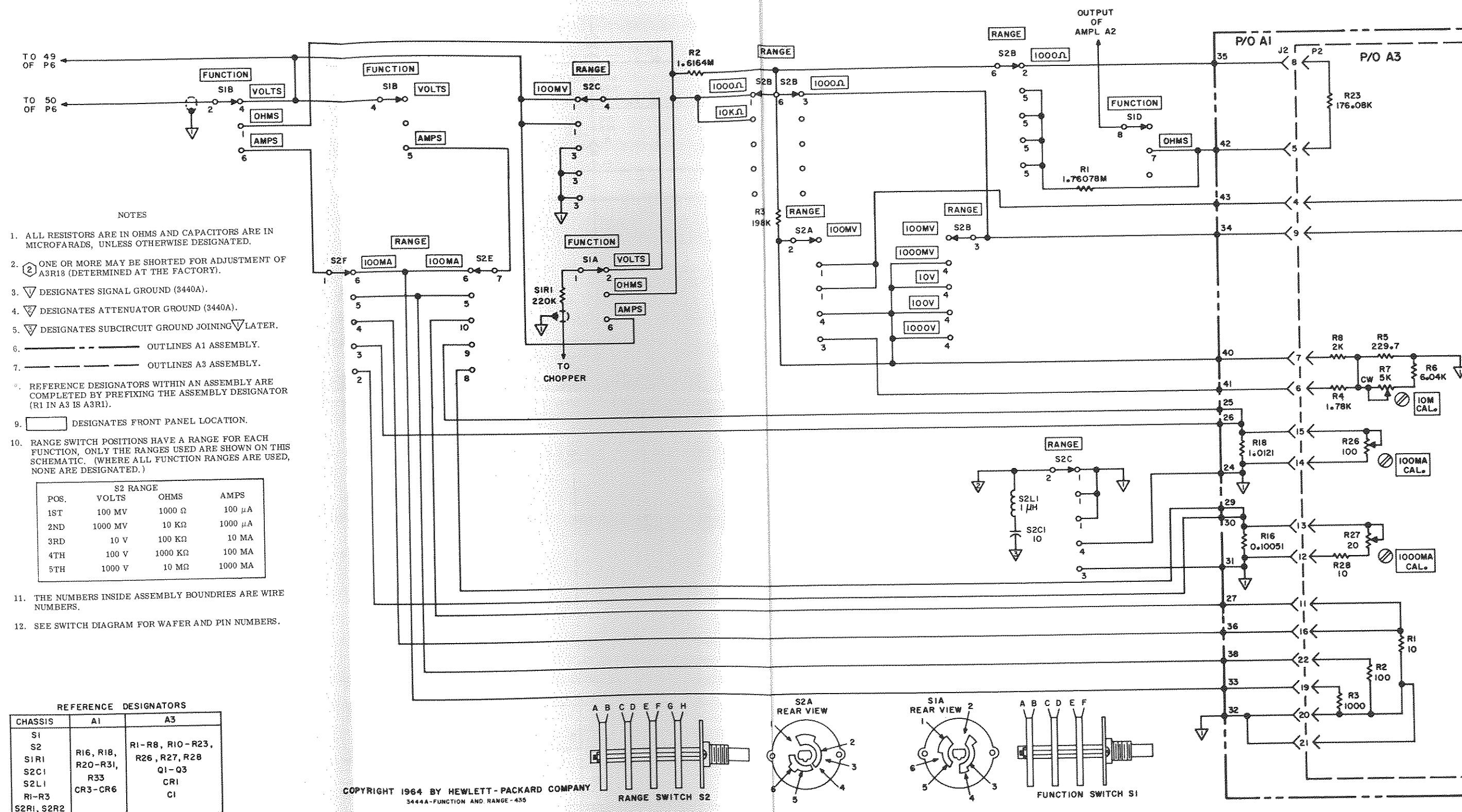


Figure 5-15. Amplifier Schematic, Part 1



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3444A-AMPLIFIER-435

Figure 5-15. Amplifier Schematic, Part 2

Section V
Figure 5-16

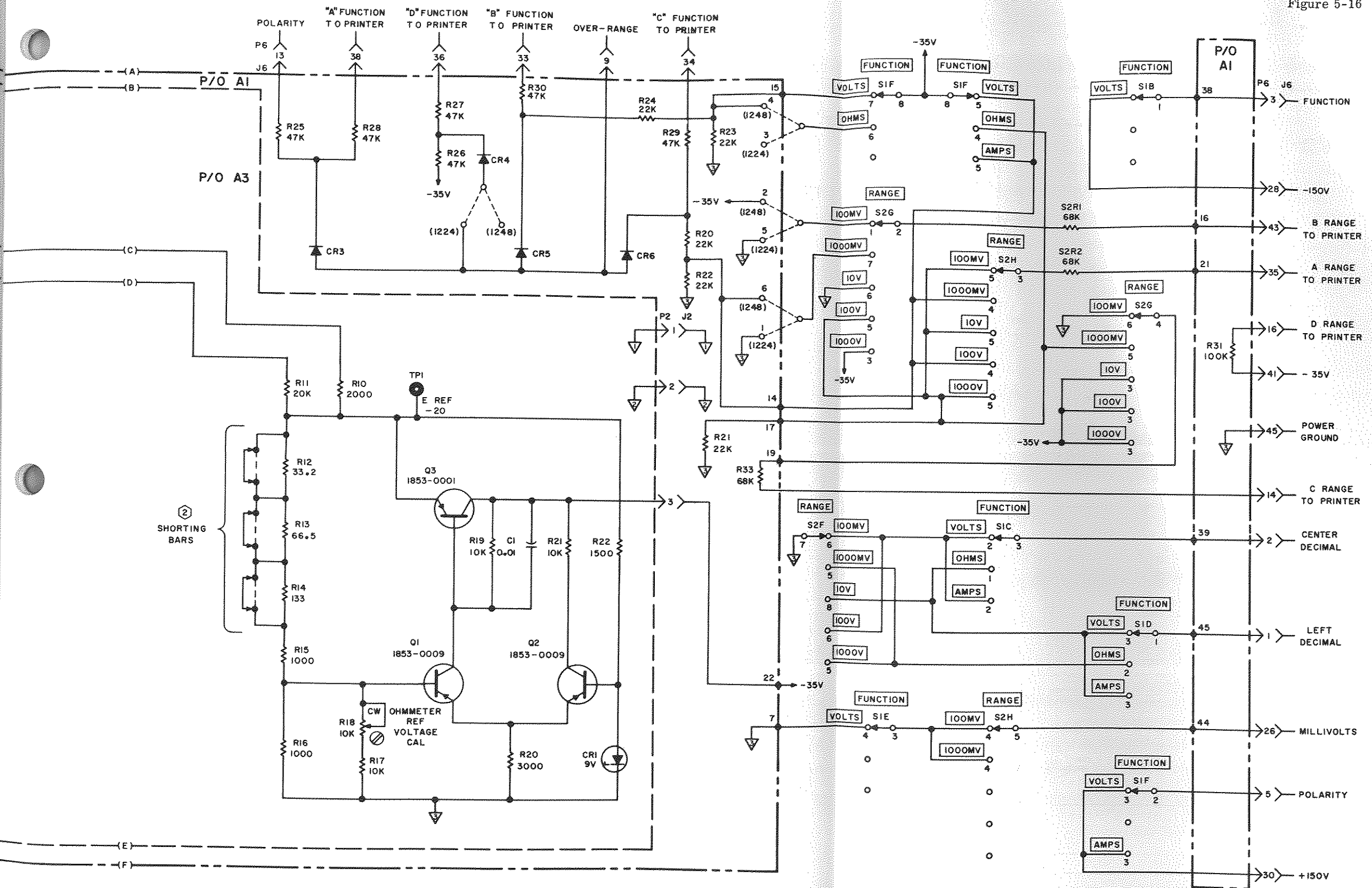


Figure 5-16. Function and Range Schematic, Part 2

SECTION VI

REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alpha-numerical order of their reference designators and indicates the description and Φ stock number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their Φ stock number and provides the following information on each part:

- a. Description of the part (see list of abbreviations below).
- b. Typical manufacturer of the part in a five-digit code (see list of manufacturers in Appendix).
- c. Manufacturer's part number.
- d. Total quantity used in the instrument (TQ column).

6-3. Miscellaneous parts are listed at the end of Table 6-1.

6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office (see maps at rear of this manual for addresses. Identify parts by their Hewlett-Packard stock numbers.

6-6. NON-LISTED PARTS.

6-7. To obtain a part that is not listed, include:

- a. Instrument model number.
- b. Instrument serial number.
- c. Description of the part.
- d. Function and location of the part.

REFERENCE DESIGNATORS

A = assembly	F = fuse	P = plug	V = vacuum tube, neon bulb, photocell, etc.
B = motor	FL = filter	Q = transistor	W = cable
C = capacitor	J = jack	R = resistor	X = socket
CR = diode	K = relay	RT = thermistor	XF = fuseholder
DL = delay line	L = inductor	S = switch	XDS = lampholder
DS = device signaling (lamp)	M = meter	T = transformer	Z = network
E = misc electronic part	MP = mechanical part		

ABBREVIATIONS

a = amperes	elect = electrolytic	mtg = mounting	rot = rotary
bp = bandpass	encap = encapsulated	my = mylar	rms = root-mean-square
bwo = backward wave oscillator	f = farads	NC = normally closed	rmo = rack mount only
c = carbon	fxd = fixed	Ne = neon	s-b = slow-blow
cer = ceramic	Ge = germanium	NO = normally open	Se = selenium
cmo = cabinet mount only	grd = ground (ed)	NPO = negative positive zero (zero temperature coefficient)	sect = section(s)
coef = coefficient	h = henries	nsr = not separately replaceable	Si = silicon
com = common	Hg = mercury	obd = order by description	sil = silver
comp = composition	imp = impregnated	p = peak	sl = slide
conn = connection	incd = incandescent	pc = printed circuit board	td = time delay
crt = cathode-ray tube	ins = insulation (ed)	pf = picofarads = 10^{-12} farads	TiO ₂ = titanium dioxide
dep = deposited	K = kilo = 1000	pp = peak to peak	tog = toggle
EIA = Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by Φ stock numbers.	lin = linear taper	piv = peak inverse voltage	tol = tolerance
	log = logarithmic taper	pos = position (s)	trim = trimmer
	m = milli = 10^{-3}	pot = potentiometer	tw = traveling wave tube
	M = megohms	rect = rectifier	var = variable
	ma = milliamperes		w/ = with
	μ = micro = 10^{-6}		W = watts
	minat = miniature		ww = wirewound
	mfgl = metal film on glass		w/o = without
	mfr = manufacturer		* = optimum value selected at factory, average value shown (part may be omitted)

Table 6-1. Reference Designation Index

Circuit Reference	Stock No.	Description	Note
A1	03444-66501	Board, master, A-1, includes: C1 thru C5 R1 thru R37 CR1 thru CR6	
A1C1	0160-0871	C: fxd, mylar die, 2.0 μ f $\pm$ 20%, 30 vdcw	
A1C2, A1C3	0180-0089	C: fxd, elect, 10 μ f -10% +100%, 150 vdcw	
A1C4	0180-0269	C: fxd, elect alum, 1 μ f -10% +75%, 150 vdcw	
A1C5	0160-0168	C: fxd, 0.1 μ f $\pm$ 10%	
A1CR1, A1CR2		Not assigned	
A1CR3 thru A1CR6	1901-0025	Diode, silicon, 50 ma at +1 v, 100 piv, 12 pf	
A1R1	0692-6845	R: fxd, comp, 680 K ohms $\pm$ 5%, 2 w	
A1R2 thru A1R4		Not assigned	
A1R5	0683-8255	R: fxd, comp, 8.2 M ohms $\pm$ 5%, 1/4 w	
A1R6	0683-1015	R: fxd, comp, 100 ohms $\pm$ 5%, 1/4 w	
A1R7	0811-0911	R: fxd, prec, ww, 10.114 K ohms $\pm$ 0.1%, 0.1 w	
A1R8	0683-2025	R: fxd, comp, 2000 ohms $\pm$ 5%, 1/4 w	
A1R9	2100-0084	R: var, lin taper, comp, 50 K ohms $\pm$ 20%, 1/3 w	
A1R10	0692-1235	R: fxd, comp, 12 K ohms $\pm$ 5%, 2 w	
A1R11	0686-1825	R: fxd, comp, 1800 ohms $\pm$ 5%, 1/2 w	
A1R12	0683-8245	R: fxd, comp, 820 K ohms $\pm$ 5%, 1/4 w	
A1R13	0683-1045	R: fxd, comp, 100 K ohms $\pm$ 5%, 1/4 w	
A1R14, A1R15		Not assigned	
A1R16	0811-0394	R: fxd, prec, ww, 0.10051 ohms $\pm$ 0.1%, 0.1 w	
A1R17		Not assigned	
A1R18	0811-0395	R: fxd, prec, ww, 1.0121 ohms $\pm$ 0.1%, 0.1 w	
A1R19		Not assigned	
A1R20 thru A1R24	0683-2235	R: fxd, comp, 22 K ohms $\pm$ 5%, 1/4 w	
A1R25 thru A1R30	0683-4735	R: fxd, comp, 47 K ohms $\pm$ 5%, 1/4 w	
A1R31	0683-1045	R: fxd, comp, 100 K ohms $\pm$ 5%, 1/4 w	
A1R32		Not assigned	
A1R33	0684-6831	R: fxd, comp, 68 K ohms $\pm$ 10%, 1/4 w	
A1R34 thru A1R36		Not assigned	
A1R37	0683-1265	R: fxd, comp, 12 M ohms $\pm$ 5%, 1/4 w	
A2	03444-66502	Board, amplifier, A-2, includes: C1 thru C9 R1 thru R36 CR1 thru CR7 TP1 thru TP3 Q1 thru Q7	
A2C1	0140-0200	C: fxd, dipped mica, 390 pf $\pm$ 5%	
A2C2	0180-0059	C: fxd, elect, 10 μ f -10% +100%, 25 vdcw	
A2C3	0180-0076	C: fxd, elect, 20 μ f, 25 vdcw	
A2C4	0160-0168	C: fxd, 0.1 μ f $\pm$ 10%	
A2C5	0160-0154	C: fxd, 2200 pf $\pm$ 10%	
A2C6	0180-0061	C: fxd, elect, 100 μ f +100% -10%, 15 vdcw	
A2C7	0170-0038	C: fxd, mylar die, 0.22 μ f $\pm$ 10%, 200 vdcw	
A2C8	0150-0015	C: fxd, TiO ₂ die, 2.2 pf $\pm$ 10%, 500 vdcw	
A2C9	0180-0294	C: fxd, elect Ta, 390 μ f $\pm$ 20%, 10 vdcw	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Ⓢ Stock No.	Description	Note
A2CR1, A2CR2	1901-0025	Diode, silicon, 50 ma at +1 v, 100 piv, 12 pf	
A2CR3	1902-0197	Diode, breakdown, 82 v $\pm 5\%$, 1 w	
A2CR4, A2CR5	1901-0025	Diode, silicon, 50 ma at +1 v, 100 piv, 12 pf	
A2CR6	1902-0049	Diode, breakdown, 6.5 v $\pm 5\%$	
A2CR7	1902-0182	Diode, breakdown, 20 v $\pm 5\%$	
A2Q1	1854-0023	Transistor, NPN silicon, similar to 2N2484	
A2Q2, A2Q3	1854-0029	Transistor, EIA type 2N2712, NPN silicon	
A2Q4	1850-0128 1205-0002	Transistor, EIA type 2N398B, PNP germanium Heat sink, transistor, circular, with slots to increase radiating surface	
A2Q5, A2Q6	1854-0029	Transistor, EIA type 2N2712, NPN silicon	
A2Q7	1853-0001	Transistor, PNP silicon, similar to 2N1132	
A2R1	0683-2055	R: fxd, comp, 2 M ohms $\pm 5\%$, 1/4 w	
A2R2	0683-6845	R: fxd, comp, 680 K ohms $\pm 5\%$, 1/4 w	
A2R3	0683-1035	R: fxd, comp, 10 K ohms $\pm 5\%$, 1/4 w	
A2R4	0683-1025	R: fxd, comp, 1000 ohms $\pm 5\%$, 1/4 w	
A2R5	0683-1045	R: fxd, comp, 100 K ohms $\pm 5\%$, 1/4 w	
A2R6	0683-2455	R: fxd, comp, 2.4 M ohms $\pm 5\%$, 1/4 w	
A2R7	0683-1065	R: fxd, comp, 10 M ohms $\pm 5\%$, 1/4 w	
A2R8	0683-6845	R: fxd, comp, 680 K ohms $\pm 5\%$, 1/4 w	
A2R9	0683-1025	R: fxd, comp, 1000 ohms $\pm 5\%$, 1/4 w	
A2R10	0683-6835	R: fxd, comp, 68 K ohms $\pm 5\%$, 1/4 w	
A2R11	0683-1535	R: fxd, comp, 15 K ohms $\pm 5\%$, 1/4 w	
A2R12	0683-1035	R: fxd, comp, 10 K ohms $\pm 5\%$, 1/4 w	
A2R13	0683-4745	R: fxd, comp, 470 K ohms $\pm 5\%$, 1/4 w	
A2R14	0683-6845	R: fxd, comp, 680 K ohms $\pm 5\%$, 1/4 w	
A2R15	0683-3325	R: fxd, comp, 3300 ohms $\pm 5\%$, 1/4 w	
A2R16	0683-2225	R: fxd, comp, 2200 ohms $\pm 5\%$, 1/4 w	
A2R17	0683-1235	R: fxd, comp, 12 K ohms $\pm 5\%$, 1/4 w	
A2R18	0758-0047	R: fxd, metal-oxide flm, 7.5 K ohms $\pm 5\%$, 1/2 w	
A2R19	0683-2035	R: fxd, comp, 20 K ohms $\pm 5\%$, 1/4 w	
A2R20	0683-1015	R: fxd, comp, 100 ohms $\pm 5\%$, 1/4 w	
A2R21, A2R22	0683-4705	R: fxd, comp, 47 ohms $\pm 5\%$, 1/4 w	
A2R23	0683-5625	R: fxd, comp, 5600 ohms $\pm 5\%$, 1/4 w	
A2R24	0683-5645	R: fxd, comp, 560 K ohms $\pm 5\%$, 1/4 w	
A2R25	0683-3045	R: fxd, comp, 300 K ohms $\pm 5\%$, 1/4 w	
A2R26	0683-1045	R: fxd, comp, 100 K ohms $\pm 5\%$, 1/4 w	
A2R27	0698-0060	R: fxd, comp, 3.6 M ohms $\pm 5\%$, 1/4 w	
A2R28	0683-1035	R: fxd, comp, 10 K ohms $\pm 5\%$, 1/4 w	
A2R29	0683-1045	R: fxd, comp, 100 K ohms $\pm 5\%$, 1/4 w	
A2R30	0683-1845	R: fxd, comp, 180 K ohms $\pm 5\%$, 1/4 w	
A2R31	2100-0962	R: var, comp, lin, 3 K ohms $\pm 30\%$, 1/4 w	
A2R32	0683-3025	R: fxd, comp, 3000 ohms $\pm 5\%$, 1/4 w	
A2R33	0811-0140	R: fxd, ww, 895 K ohms $\pm 0.2\%$, 0.25 w	
A2R34	2100-0888	R: var, prec ww, 10 K ohms $\pm 10\%$, 0.5 w	
A2R35	0811-0370	R: fxd, ww, 89.5 K ohms $\pm 0.1\%$, 0.1 w	
A2R36	2100-0889	R: var, prec ww, 1000 ohms $\pm 10\%$, 0.5 w	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description	Note
A2TP1	0360-0124	Terminal, pin, for 3/32" printed circuit board	
A2TP2, A2TP3	0360-0435	Terminal, board, pin, silver-plated brass	
A3	03444-66503	Board, function, A-3, includes: C1 R1 thru R28 CR1 TP1 Q1 thru Q3	
A3C1	0160-0161	C: fxd, 0.01 μ f $\pm$ 10%	
A3CR1	1902-0071	Diode, breakdown, silicon, 9 v $\pm$ 5%	
A3Q1, A3Q2	1853-0009	Transistor, PNP silicon	
A3Q3	1853-0001	Transistor, PNP silicon, similar to 2N1132	
A3R1	0811-0396	R: fxd, prec ww, 10 ohms $\pm$ 0.025%, 1/4 w	
A3R2	0811-0397	R: fxd, prec ww, 100 ohms $\pm$ 0.025%, 1/4 w	
A3R3	0811-0403	R: fxd, prec ww, 1000 ohms $\pm$ 0.025%, 1/4 w	
A3R4	0757-1022	R: fxd, met flm, 1.78 K ohms $\pm$ 1%, 1/4 w	
A3R5	0811-0400	R: fxd, prec ww, 229.7 ohms $\pm$ 0.1%, 1/2 w	
A3R6	0757-1023	R: fxd, met flm, 6.04 K ohms $\pm$ 1%, 1/4 w	
A3R7	2100-0974	R: var, prec ww, 5 K ohms $\pm$ 10%, 0.5 w	
A3R8	0811-0404	R: fxd, prec ww, 2000 ohms $\pm$ 0.01%, 1/4 w	
A3R9		Not assigned	
A3R10	0757-0739	R: fxd, met flm, 2 K ohms $\pm$ 1%, 1/4 w	
A3R11	0811-0408	R: fxd, prec ww, 20 K ohms $\pm$ 0.01%, 1/4 w	
A3R12	0757-0389	R: fxd, met flm, 33.2 ohms $\pm$ 1%, 1/8 w	
A3R13	0757-1021	R: fxd, met flm, 66.5 ohms $\pm$ 1%, 1/4 w	
A3R14	0757-1020	R: fxd, met flm, 133 ohms $\pm$ 1%, 1/4 w	
A3R15, A3R16	03444-86701	R: ww, 1000 ohms (matched pair)	
A3R17	0757-0340	R: fxd, met flm, 10 K ohms $\pm$ 1%, 1/4 w	
A3R18	2100-0888	R: var, prec ww, 10 K ohms $\pm$ 10%, 0.5 w	
A3R19	0683-1035	R: fxd, comp, 10 K ohms $\pm$ 5%, 1/4 w	
A3R20	0683-3025	R: fxd, comp, 3000 ohms $\pm$ 5%, 1/4 w	
A3R21	0683-1035	R: fxd, comp, 10 K ohms $\pm$ 5%, 1/4 w	
A3R22	0757-0736	R: fxd, met flm, 1.5 K ohms $\pm$ 1%, 1/4 w	
A3R23	0811-0409	R: fxd, prec, ww, 176.08 K ohms $\pm$ 0.1%, 0.1 w	
A3R24, A3R25		Not assigned	
A3R26	2100-0973	R: var, prec ww, 100 ohms $\pm$ 10%, 0.5 w	
A3R27	2100-0972	R: var, prec ww, 20 ohms $\pm$ 10%, 0.5 w	
A3R28	0757-0346	R: fxd, met flm, 10 ohms $\pm$ 1%, 1/8 w	
A3TP1	0360-0124	Terminal, pin, for 3/32" printed circuit board	
A4	03444-62801	Filter, chopper assy, includes: C1, C2 R1 CR1, CR2	
	1990-0026	Photochopper assy, includes: C3, C4 R2 thru R4 CR3, CR4 V1 thru V4 DS1 thru DS3	
A4C1	0170-0038	C: fxd, mylar die, 0.22 μ f $\pm$ 10%, 200 vdcw	
A4C2	0170-0053	C: fxd, poly die, 0.033 μ f $\pm$ 5%, 50 vdcw	
A4CR1, A4CR2	1901-0156	Diode, silicon, 50 ma at 1 v, 20 piv	

See introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Circuit Reference	Stock No.	Description	Note
A4R1	0686-2245	R: fxd, comp, 220 K ohms $\pm 5\%$, 1/2 w	
C3	0160-0743	C: fxd, poly die, 0.015 μf $\pm 20\%$, 50 vdcw	
J1, J2	1251-0465	Connector, printed circuit, 22 tuning fork type contacts, dip solder terminals	
P6	1251-1025	Connector, male, 50 contacts, rack and panel plug	
R1	0811-0412	R: fxd, prec, ww, 1.76078 M ohms $\pm 0.05\%$, 1/4 w	
R2	0811-0411	R: fxd, prec ww, 1.6164 M ohms $\pm 0.02\%$, 1/4 w	
R3	0811-0410	R: fxd, prec ww, 198 K ohms $\pm 0.02\%$, 1/4 w	
R4	2100-0172	R: var, lin taper comp, 3 M ohms $\pm 20\%$, 1/4 w	
S1	3100-0847	Switch, rotary, 3-position, 3-section	
S1R1	0693-2241	R: fxd, comp, 220 K ohms $\pm 10\%$, 2 w	
S2	3100-0848	Switch, rotary, 5-position, 4-section	
S2C1	0180-0224	C: fxd, elect alum, 10 μf -10% $+75\%$, 15 vdcw	
S2L1	9140-0018	Coil, electromagnetic, RF, choke, single layer wound, unshielded, 1 μh	
S2R1, S2R2	0684-6831	R: fxd, comp, 68 K ohms $\pm 10\%$, 1/4 w	
<u>MISCELLANEOUS</u>			
	0340-0008	Terminal, stand-off, round post shape, teflon	
	0340-0038	Post, terminal, use with 0340-0039 to form insulated feed-through terminal	
	0340-0039	Bushing, insulator, for stand-off terminals and feed-through terminals	
	0370-0077	Knob, bar	
	0370-0088	Knob, latch, round, 5/8" diam, black, for 1/4" diam shaft	
	1200-0081	Insulator, bushing, nylon, shoulder 0.235" OD, 0.115" ID	
	1390-0029	Fastener, latch, adjustable pawl, clockwise locking, less knob	
	1410-0052	Bushing, pot, 0.435" OD by 0.438" lg	
	03444-00201	Panel, front	
	03444-00202	Panel, rear	
	03444-00203	Panel, sub	
	03444-01201	Bracket, board	
	03444-04101	Plate, insulating	
	03444-90000	Manual	

Table 6-2. Replaceable Parts

Stock No.	Description	Mfr.	Mfr. Part No.	TQ			
0140-0200	C: fxd, dipped mica, 390 pf $\pm 5\%$	00853	RDM15F391J3C	1			
0150-0015	C: fxd, TiO_2 die, 2.2 pf $\pm 10\%$, 500 vdcw	82142	type JM obd#	1			
0160-0154	C: fxd, 2200 pf $\pm 10\%$	56289	192P22292	1			
0160-0161	C: fxd, 0.01 μf $\pm 10\%$	56289	192P10392	1			
0160-0168	C: fxd, 0.1 μf $\pm 10\%$	56289	192P10492	2			
0160-0743	C: fxd, poly die, 0.015 μf $\pm 20\%$, 50 vdcw	56289	194P1530R5	1			
0160-0871	C: fxd, mylar die, 2.0 μf $\pm 20\%$, 30 vdcw	56289	148P obd#	1			
0170-0038	C: fxd, mylar die, 0.22 μf $\pm 10\%$, 200 vdcw	56289	type 148P 148P22492	2			
0170-0053	C: fxd, poly die, 0.033 μf $\pm 5\%$, 50 vdcw	56289	194P3335R5	1			
0180-0059	C: fxd, elect, 10 μf -10% $+100\%$, 25 vdcw	56289	30D106G025BB4	1			
0180-0061	C: fxd, elect, 100 μf $+100\%$ -10% , 15 vdcw	56289	30D107G015DD4	1			
0180-0076	C: fxd, elect, 20 μf , 25 vdcw	56289	40D 181 A2	1			
0180-0089	C: fxd, elect, 10 μf -10% $+100\%$, 150 vdcw	56289	30D106G150DF4	2			
0180-0224	C: fxd, elect alum, 10 μf -10% $+75\%$, 15 vdcw	56289	30D106G015BA4	1			
0180-0269	C: fxd, elect alum, 1 μf -10% $+75\%$, 150 vdcw	56289	30D105G150CC4	1			
0180-0294	C: fxd, elect, Ta, 390 μf $\pm 20\%$, 10 vdcw	06751	TSW3-10-397	1			
0340-0008	Terminal, stand-off, round post shape, teflon	98291	ST-1000-L2	2			
0340-0038	Post, terminal, use with 0340-0039 to form insulated feed-through terminal	98291	X-L-041762-10	6			
0340-0039	Bushing, insulator, for stand-off terminals and feed-through terminals	98291	X-B-04176-12	6			
0360-0124	Terminal, pin, for 3/32" printed circuit board	71279	2970-3	2			
0360-0435	Terminal, board, pin, silver-plated brass	28480	0360-0435	2			
0370-0077	Knob, bar	28480	0370-0077	2			
0370-0088	Knob, latch, round, 5/8" diam, black, for 1/4" diam shaft	28480	0370-0088	1			
0683-1015	R: fxd, comp, 100 ohms $\pm 5\%$, 1/4 w	01121	CB1015	2			
0683-1025	R: fxd, comp, 1000 ohms $\pm 5\%$, 1/4 w	01121	CB1025	2			
0683-1035	R: fxd, comp, 10 K ohms $\pm 5\%$, 1/4 w	01121	CB1035	5			
0683-1045	R: fxd, comp, 100 K ohms $\pm 5\%$, 1/4 w	01121	CB1045	5			
0683-1065	R: fxd, comp, 10 M ohms $\pm 5\%$, 1/4 w	01121	CB1065	1			
0683-1235	R: fxd, comp, 12 K ohms $\pm 5\%$, 1/4 w	01121	CB1235	1			
0683-1265	R: fxd, comp, 12 M ohms $\pm 5\%$, 1/4 w	01121	CB1265	1			
0683-1535	R: fxd, comp, 15 K ohms $\pm 5\%$, 1/4 w	01121	CB1535	1			
0683-1845	R: fxd, comp, 180 K ohms $\pm 5\%$, 1/4 w	01121	CB1845	1			
0683-2025	R: fxd, comp, 2000 ohms $\pm 5\%$, 1/4 w	01121	CB2025	1			
0683-2035	R: fxd, comp, 20 K ohms $\pm 5\%$, 1/4 w	01121	CB2035	1			
0683-2055	R: fxd, comp, 2 M ohms $\pm 5\%$, 1/4 w	28480	0683-2055	1			
0683-2225	R: fxd, comp, 2200 ohms $\pm 5\%$, 1/4 w	01121	CB2225	1			
0683-2235	R: fxd, comp, 22 K ohms $\pm 5\%$, 1/4 w	01121	CB2235	5			
0683-2455	R: fxd, comp, 2.4 M ohms $\pm 5\%$, 1/4 w	01121	CB2455	1			
0683-3025	R: fxd, comp, 3000 ohms $\pm 5\%$, 1/4 w	01121	CB3025	2			
0683-3045	R: fxd, comp, 300 K ohms $\pm 5\%$, 1/4 w	01121	CB3045	1			
0683-3325	R: fxd, comp, 3300 ohms $\pm 5\%$, 1/4 w	01121	CB3325	1			
0683-4705	R: fxd, comp, 47 ohms $\pm 5\%$, 1/4 w	01121	CB4705	2			
0683-4735	R: fxd, comp, 47 K ohms $\pm 5\%$, 1/4 w	01121	CB4735	6			
0683-4745	R: fxd, comp, 470 K ohms $\pm 5\%$, 1/4 w	01121	CB4745	1			
0683-5625	R: fxd, comp, 5600 ohms $\pm 5\%$, 1/4 w	01121	CB5625	1			
0683-5645	R: fxd, comp, 560 K ohms $\pm 5\%$, 1/4 w	01121	CB5645	1			

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description	Mfr.	Mfr. Part No.	TQ			
0683-6835	R: fxd, comp, 68 K ohms $\pm 5\%$, 1/4 w	01121	CB6835	1			
0683-6845	R: fxd, comp, 680 K ohms $\pm 5\%$, 1/4 w	01121	CB6845	3			
0683-8245	R: fxd, comp, 820 K ohms $\pm 5\%$, 1/4 w	01121	CB8245	1			
0683-8255	R: fxd, comp, 8.2 M ohms $\pm 5\%$, 1/4 w	01121	CB8255	1			
0684-6831	R: fxd, comp, 68 K ohms $\pm 10\%$, 1/4 w	01121	CB6831	3			
0686-1825	R: fxd, comp, 1800 ohms $\pm 5\%$, 1/2 w	01121	EB1825	1			
0686-2245	R: fxd, comp, 220 K ohms $\pm 5\%$, 1/2 w	01121	EB2245	1			
0692-1235	R: fxd, comp, 12 K ohms $\pm 5\%$, 2 w	01121	HB1235	1			
0692-6845	R: fxd, comp, 680 K ohms $\pm 5\%$, 2 w	01121	HB6845	1			
0693-2241	R: fxd, comp, 220 K ohms $\pm 10\%$, 2 w	01121	HB2241	1			
0698-0060	R: fxd, comp, 3.6 M ohms $\pm 5\%$, 1/4 w	01121	CB3655	1			
0757-0340	R: fxd, met flm, 10 K ohms $\pm 1\%$, 1/4 w	19701	MF6C T-O obd#	1			
0757-0346	R: fxd, met flm, 10 ohms $\pm 1\%$, 1/8 w	19701	MF5C T-O obd#	1			
0757-0389	R: fxd, met flm, 33.2 ohms $\pm 1\%$, 1/8 w	75042	CEA T-O obd#	1			
0757-0736	R: fxd, met flm, 1.5 K ohms $\pm 1\%$, 1/4 w	75042	CEB T-O obd#	1			
0757-0739	R: fxd, met flm, 2 K ohms $\pm 1\%$, 1/4 w	75042	CEB T-O obd#	1			
0757-1020	R: fxd, met flm, 133 ohms $\pm 1\%$, 1/4 w	75042	CEB T-O obd#	1			
0757-1021	R: fxd, met flm, 66.5 ohms $\pm 1\%$, 1/4 w	75042	CEB T-O obd#	1			
0757-1022	R: fxd, met flm, 1.78 K ohms $\pm 1\%$, 1/4 w	75042	CEB T-O obd#	1			
0757-1023	R: fxd, met flm, 6.04 K ohms $\pm 1\%$, 1/4 w	75042	CEB T-O obd#	1			
0758-0047	R: fxd, metal-oxide flm, 7.5 K ohms $\pm 5\%$, 1/2 w	07115	C20 obd#	1			
0811-0140	R: fxd, ww, 895 K ohms $\pm 0.2\%$, 0.25 w	05347	510A obd#	1			
0811-0370	R: fxd, ww, 89.5 K ohms $\pm 0.1\%$, 0.1 w	28480	0811-0370	1			
0811-0394	R: fxd, prec ww, 0.10051 ohms $\pm 0.1\%$, 0.1 w	28480	0811-0394	1			
0811-0395	R: fxd, prec ww, 1.0121 ohms $\pm 0.1\%$, 0.1 w	28480	0811-0395	1			
0811-0396	R: fxd, prec ww, 10 ohms $\pm 0.025\%$, 1/4 w	28480	0811-0396	1			
0811-0397	R: fxd, prec ww, 100 ohms $\pm 0.025\%$, 1/4 w	28480	0811-0397	1			
0811-0400	R: fxd, prec ww, 229.7 ohms $\pm 0.1\%$, 1/2 w	28480	0811-0400	1			
0811-0403	R: fxd, prec ww, 1000 ohms $\pm 0.025\%$, 1/4 w	28480	0811-0403	1			
0811-0404	R: fxd, prec ww, 2000 ohms $\pm 0.01\%$, 1/4 w	28480	0811-0404	1			
0811-0408	R: fxd, prec ww, 20 K ohms $\pm 0.01\%$, 1/4 w	28480	0811-0408	1			
0811-0409	R: fxd, prec ww, 176.08 K ohms $\pm 0.1\%$, 0.1 w	28480	0811-0409	1			
0811-0410	R: fxd, prec ww, 198 K ohms $\pm 0.02\%$, 1/4 w	28480	0811-0410	1			
0811-0411	R: fxd, prec ww, 1.6164 M ohms $\pm 0.02\%$, 1/4 w	28480	0811-0411	1			
0811-0412	R: fxd, prec ww, 1.76078 M ohms $\pm 0.05\%$, 1/4 w	28480	0811-0412	1			
0811-0911	R: fxd, prec ww, 10.114 K ohms $\pm 0.1\%$, 0.1 w	28480	0811-0911	1			
1200-0081	Insulator, bushing, nylon, shoulder 0.235" OD, 0.115" ID	26365	974 Special obd#	2			
1205-0002	Heat sink, transistor, circular, with slots to increase radiating surface	000II	3AL 635-2R	1			
1251-0465	Connector, printed circuit, 22 tuning fork type contacts, dip solder terminals	02660	143-022-03-1115	2			
1251-1025	Connector, male, 50 contacts, rack and panel plug	71785	57-10500-23	1			
1390-0029	Fastener, latch, adjustable pawl, clockwise locking, less knob	91079	48-99-137-22	1			
1410-0052	Bushing, pot, 0.435" OD by 0.438" lg	28480	1410-0052	1			

See introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

Stock No.	Description	Mfr.	Mfr. Part No.	TQ			
1850-0128	Transistor, EIA type 2N398B, PNP germanium	01295	2N398B	1			
1853-0001	Transistor, PNP silicon, similar to 2N1132	03877	ST 8047	2			
1853-0009	Transistor, PNP silicon	01295	SM5727	2			
1854-0023	Transistor, NPN silicon, similar to 2N2484	00872	A-1081	1			
1854-0029	Transistor, EIA type 2N2712, NPN silicon	24446	2N2712	4			
1901-0025	Diode, silicon, 50 ma at +1 v, 100 piv, 12 pf	28480	1901-0025	8			
1901-0156	Diode, silicon, 50 ma at 1 v, 20 piv	03877	SG 3288	2			
1902-0049	Diode, breakdown, 6.5 v $\pm 5\%$	04713	SZ10939-122	1			
1902-0071	Diode, breakdown, silicon, 9 v $\pm 5\%$	28480	1902-0071	1			
1902-0182	Diode, breakdown, 20 v $\pm 5\%$	04713	SZ10939-272	1			
1902-0197	Diode, breakdown, 82 v $\pm 5\%$, 1 w	04713	IN3042B	1			
1990-0026	Photochopper assy	28480	1990-0026	1			
2100-0084	R: var, lin taper, comp, 50 K ohms $\pm 20\%$, 1/3 w	11237	Type UPM-45 obd#	1			
2100-0172	R: var, lin taper comp, 3 M ohms $\pm 20\%$, 1/4 w	11237	Type 45 obd#	1			
2100-0888	R: var, prec ww, 10 K ohms $\pm 10\%$, 0.5 w	80294	236P-1-103	2			
2100-0889	R: var, prec ww, 1000 ohms $\pm 10\%$, 0.5 w	80294	236P-1-102	1			
2100-0962	R: var, comp, lin, 3 K ohms $\pm 30\%$, 1/4 w	76055	MTC-1 obd#	1			
2100-0972	R: var, prec ww, 20 ohms $\pm 10\%$, 0.5 w	80294	236P-1-101	1			
2100-0973	R: var, prec ww, 100 ohms $\pm 10\%$, 0.5 w	80294	236P-1-200	1			
2100-0974	R: var, prec ww, 5 K ohms $\pm 10\%$, 0.5 w	80294	236P-1-502	1			
3100-0847	Switch, rotary, 3-position, 3-section	76854	obd#	1			
3100-0848	Switch, rotary, 5-position, 4-section	76854	obd#	1			
9140-0018	Coil, electromagnetic, RF, choke, single layer wound, unshielded, 1 μ h	78526	H-9977	1			
03444-00201	Panel, front	28480	03444-00201	1			
03444-00202	Panel, rear	28480	03444-00202	1			
03444-00203	Panel, sub	28480	03444-00203	1			
03444-01201	Bracket, board	28480	03444-01201	1			
03444-04101	Plate, insulating	28480	03444-04101	1			
03444-62801	Filter, chopper assy	28480	03444-62801	1			
03444-66501	Board, master A-1	28480	03444-66501	1			
03444-66502	Board, amplifier A-2	28480	03444-66502	1			
03444-66503	Board, function, A-3	28480	03444-66503	1			
03444-86701	R: ww, 1000 ohms (matched pair)	28480	03444-82601	1			
03444-90000	Manual	28480	03444-90000	1			

APPENDIX CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been assigned to suppliers not appearing in the H4 handbooks.

Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address
00000	U. S. A. Common	Any supplier of U. S.	01749	Fillehm Corp.	New York, N. Y.	49956	Raytheon Company	Lexington, Mass.	74970	E. F. Johnson Co.	Waseca, Minn.
00136	McDoy Electronics	Mount Holly Springs, Pa.	07233	Cinch-Graphix Co.	City of Industry, Calif.	52090	Rowan Controller Co.	Baltimore, Md.	75042	International Resistance Co.	Philadelphia, Pa.
00213	Sage Electronics Corp.	Rochester, N. Y.	07261	Avnet Corp.	Los Angeles, Calif.	63743	Ward Leonard Electric	Mt. Vernon, N. Y.	75173	Jones, Howard B., Division	Chicago, Ill.
00334	Humidall Co.	Colton, Calif.	07263	Fairchild Semiconductor Corp.	Mountain View, Calif.	54294	Shallcross Mfg. Co.	Selma, N. C.	75378	James Knights Co.	Sandwich, Ill.
00335	Westech Corp.	New York, N. Y.	07322	Minnesota Rubber Co.	Minneapolis, Minn.	55026	Simpson Electric Co.	Chicago, Ill.	75382	Kulka Electric Corporation	Mt. Vernon, N. Y.
00373	Garlock Packing Co.,	Camden, N. J.	07387	The Birtcher Corp.	Los Angeles, Calif.	55933	Sorenson & Co., Inc.	So. Norwalk, Conn.	75818	Lenz Electric Mfg. Co.	Chicago, Ill.
00656	Aerovox Corp.	New Bedford, Mass.	07709	Technical Wire Products	Springfield, N. J.	56137	Spaulding Fibre Co., Inc.	Tonawanda, N. Y.	75915	Littell Inc.	Des Plaines, Ill.
00779	Am. Inc.	Harrisburg, Pa.	07919	Continental Device Corp.	Hawthorne, Calif.	56289	Sprague Electric Co.	North Adams, Mass.	76005	Lord Mfg. Co.	Erie, Pa.
00781	Aircraft Radio Corp.	Bloomington, N. J.	07968	Rheem Semiconductor Corp.	Mountain View, Calif.	59446	Telex, Inc.	St. Paul, Minn.	76210	C. W. Marwede	San Francisco, Calif.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.	07988	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.	59730	Thomas & Betts Co.	Elizabethtown, N. J.	76433	Micanoid Electronic Mfg. Corp.	Brooklyn, N. Y.
00853	Sangamo Electric Company,	Marion, Ill.	08145	U. S. Engineering Co.	Boston, N. J.	60741	Trigglett Electrical Inc.	St. Louis, Mo.	76487	James Millen Mfg. Co., Inc.	Malden, Mass.
00866	Gae Engineering Co.	Los Angeles, Calif.	08358	Burgess Battery Co.	Los Angeles, Calif.	61775	Union Switch and Signal, Div. of	Swissvale, Pa.	76493	J. W. Miller Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.	08717	Shoan Company	Niagara Falls, Ontario, Canada.	62119	Westinghouse Air Brake Co.	Owosso, Mich.	76530	Monadnock Mills	Cleveland, Ohio
01121	Allen Bradley Co.	Milwaukee, Wis.	08718	Canon Electric Co. Phoenix Div.	Phoenix, Ariz.	62143	Ward-Leonard Electric Co.	Mt. Vernon, N. Y.	76545	Muehler Electric Co.	Crystal Lake, Ill.
01255	Liton Industries, Inc.	Beverly Hills, Calif.	08792	CBS Electronics Semiconductor Operations, Div. of C. B. S., Inc.	Lowell, Mass.	64959	Western Electric Co., Inc.	New York, N. Y.	76854	Oak Manufacturing Corp.	Crystal Lake, Ill.
01281	TRW Semiconductor Inc.	Lawrenceville, Calif.	08984	Mel-Ron	Indianapolis, Ind.	65092	Western Inst. Div. of Daystrom, Inc.	Newark, N. J.	77068	Bendix Pacific Division of	Na, Hollywood, Calif.
01295	Texas Instruments, Inc.	Dallas, Texas	09026	Babcock Relays, Inc.	Costa Mesa, Calif.	65295	Wittet Manufacturing Co.	Chicago 23, Ill.	77271	Pacific Metals Co.	San Francisco, Calif.
01349	The Alliance Mfg. Co.	Alliance, Ohio	09145	Texas Capacitor Co.	Houston, Texas	66246	Wollensack Optical Co.	Rochester, N. Y.	77272	Phaeton Instrument and	South Pasadena, Calif.
01361	Chassis-Trak Corp.	Indianapolis, Ind.	09145	Van Rys, Calif.	San Valley, Calif.	70276	Allen Mfg. Co.	Hartford, Conn.	77250	Phoenix Mfg. Co.	Chicago, Ill.
01389	Pacific Relays, Inc.	Rockford, Ill.	09250	Alchem Electronics	Chicago, Ill.	70309	Alitel Control Co., Inc.	New York, N. Y.	77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
01930	Aerocock Corp.	Santa Clara, Calif.	09569	Electro Assemblies, Inc.	Toronto, Ontario, Canada	70319	Almetal Steel Prod. Co., Inc.	Garden City, N. Y.	77342	Potter and Brunfield, Div. of American	Pinceton, Ind.
01961	Pulse Engineering Co.	Saugerties, N. Y.	09664	The Bristol Co.	Waterbury, Conn.	70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.	77630	Radio Condenser Co.	Brooklyn, N. Y.
02114	Petrocube Corp. of America	Chicago, Ill.	10214	General Transistor Western Corp.	Los Angeles, Calif.	70563	Angerite Co., Inc.	New York, N. Y.	77638	Radio Receiver Co., Inc.	Brooklyn, N. Y.
02236	Cole Mfg. Co.	Palto Alto, Calif.	10411	Ti-Tal, Inc.	Berkeley, Calif.	70996	Bird Electronic Corp.	Cleveland, Ohio	77674	Resistance Products Co.	Harrisburg, Pa.
02260	Amphenol-Borg Electronics Corp.	Chicago, Ill.	10646	Carbotundum Co.	Niagara Falls, N. Y.	71002	Birchack Radio Co.	New York, N. Y.	77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N. J.	11236	CTS of Berne, Inc.	Berne, Ind.	71041	Boston Gear Works, Div. of	Quincy, Mass.	78189	Shakespeare Division of Hiltens	Elgin, Ill.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.	11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.	71218	Bud Radio Inc.	Cleveland, Ohio	78283	Signal Indicator Corp.	New York, N. Y.
02777	Hopkins Engineering Co.	San Fernando, Calif.	11312	Microwave Electronics Corp.	Palo Alto, Calif.	71286	Camloc Fastener Corp.	Paramus, N. J.	78290	Struthers-Dunn Inc.	Pittman, N. J.
03508	G. E. Semiconductor Products Dept.	Syracuse, N. Y.	11324	Duncan Electronic, Inc.	Santa Ana, Calif.	71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.	78452	Thompson-Bremer & Co.	Chicago, Ill.
03705	Apex Machine & Tool Co.	Dayton, Ohio	11711	General Instrument Corporation	Newark, N. J.	71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.	78471	Titley Mfg. Co.	San Francisco, Calif.
03797	Eldena Corp.	Wakfield, Mass.	11717	Imperial Electronic, Inc.	Buena Park, Calif.	71436	Chicago Condenser Corp.	Chicago, Ill.	78488	Stackpole Carbon Co.	St. Marys, Pa.
03871	Transistor Electronic Corp.	Morristown, N. J.	11870	Neelabs, Inc.	Palo Alto, Calif.	71450	CTS Corp.	Elkhart, Ind.	78493	Standard Thompson Corp.	Walham, Mass.
03886	Pyrofilm Resistor Co.	Los Angeles, Calif.	12859	Nippon Electric Co., Ltd.	Tokyo, Japan	71468	Canon Electric Co.	Los Angeles, Calif.	78553	Tinnerman Products, Inc.	Cleveland, Ohio
03954	Ar Marine Motors, Inc.	Hartford, Conn.	12859	Nippon Electric Co., Ltd.	Tokyo, Japan	71471	Cinema Engineering Co.	Burbank, Calif.	78790	Transformer Engineers	Pasadena, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	New York, N. Y.	12930	Delta Semiconductor Inc.	Newport Beach, Calif.	71482	C. P. Clare & Co.	Chicago, Ill.	78947	Unitco Co.	Newtown, Mass.
04062	Elmenco Products Co.	Myrtle Beach, S. C.	13103	Thermolyt	Dallas, Texas	71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.	79142	Veeder Root, Inc.	Hartford, Conn.
04222	H-Q Division of Aerovox	Burbank, Calif.	13136	Telefunken (G. M. B. H.)	Hannover, Germany	71700	The Cornish Wire Co.	New York, N. Y.	79251	Wenco Mfg. Co.	Chicago, Ill.
04298	Elgin National Watch Co.,	Palto Alto, Calif.	13335	Midland Mfg. Co.	Kansas City, Kansas	71744	Chicago Miniature Lamp Works	Chicago, Ill.	79252	Continental-Wart Electronics Corp.	Philadelphia, Pa.
04404	Dymec Division of Hewlett-Packard Co.	Palto Alto, Calif.	14099	Sen-Tech	Newbury Park, Calif.	71753	A. O. Smith Corp., Crowley Div.	West Orange, N. J.	79663	Zierick Mfg. Corp.	New Rochelle, N. Y.
04651	Sylvania Electric Prods., Inc.	Mountain View, Calif.	14193	Calif. Resistor Corp.	Santa Monica, Calif.	71785	Cinch Mfg. Corp.	Chicago, Ill.	80021	Nepco Division of Sessions	Morristown, N. J.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona	14298	American Components, Inc.	Conshohocken, Pa.	71784	Dow Corning Corp.	Midland, Mich.	80120	Schnitzer Alloy Products	New York, N. Y.
04732	Filton Co., Inc., Western Div.	Calver City, Calif.	14650	Cornell Duplicator Elec. Corp.	So. Plainfield, N. J.	72092	Exel McCulloch, Inc.	San Bruno, Calif.	80130	Times Facsimile Corp.	New York, N. Y.
04773	Automatic Electric Co.	Northlake, Ill.	14960	Williams Mfg. Co.	San Jose, Calif.	72136	Electro Motive Mfg. Co., Inc.	Willmaric, Conn.	80131	Electronic Industries Association.	Any brand
04777	Automatic Electric Sales Corp.	Northlake, Ill.	15909	The Daven Co.	Livingston, N. J.	71707	Coto Coil Co., Inc.	Providence, R. I.	80207	Unimax Switch, Div. of	Washington, D. C.
04796	Sequela Wire & Cable Co.	Redwood City, Calif.	16037	Source Pina Mica Co.	Spence Pine, N. C.	71707	John E. Fast & Co.	Chicago, Ill.	80223	W. L. Maxson Corp.	Wallingford, Conn.
04811	Precision Coil Spring Co.	El Monte, Calif.	16352	Computer Diode Corp.	Lodi, N. J.	72354	John E. Fast & Co.	Chicago, Ill.	80228	United Transformer Corp.	New York, N. Y.
04870	P. M. Motor Company	Chicago 44, Ill.	16688	De Jor Anso Corporation	Long Island City 1, N. Y.	72619	Dialight Corp.	Brooklyn, N. Y.	80248	Oxford Electric Corp.	Chicago, Ill.
05005	Twentieth Century Plastics, Inc.	Los Angeles, Calif.	16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.	72656	General Ceramics Corp.	Kesbey, N. J.	80294	Burns Laboratories, Inc.	Riverside, Calif.
05277	Westinghouse Electric Corp.,	Youngwood, Pa.	18873	E. J. DuPont & Co., Inc.	Wilmington, Del.	72659	General Instrument Corp.,	Newark, N. J.	80411	Acro Div. of Robertshaw	Columbus 16, Ohio
05347	Ultronic, Inc.	San Mateo, Calif.	19315	Eclipse Pioneer, Div. of	Teterboro, N. J.	72758	Grand-Hopkins	Oakland, Calif.	80466	All Star Products Inc.	Defiance, Ohio
05593	Humbert Engineering Co.	Sunnyvale, Calif.	19500	Thomas A. Edison Industries,	West Orange, N. J.	72765	Dike Mfg. Co.	Chicago, Ill.	80509	Avery Adhesive Label Corp.	Monrovia, Calif.
05624	Barber Colman Co.	Rockford, Ill.	19701	Electra Manufacturing Co.	Kansas City, Mo.	72825	Hugh H. Eby Inc.	Philadelphia, Pa.	80583	Hammerlund Co., Inc.	New York, N. Y.
05728	Tuflen Optical Co.	Roslyn Heights, Long Island, N. Y.	20183	Electronic Tube Corp.	Philadelphia, Pa.	72928	Gudeman Co.	Chicago, Ill.	80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
05729	Metropolitan Telecommunications Corp.	Brooklyn, N. Y.	21226	Executive, Inc.	New York, N. Y.	72982	Erie Resistor Corp.	Erie, Pa.	81030	International Instruments, Inc.	New Haven, Conn.
05783	Stewart Engineering Co.	Santa Cruz, Calif.	21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.	73061	Hansen Mfg. Co., Inc.	Princeton, Ind.	81073	Grayhill Co.	LaGrange, Ill.
05820	Wakefield Engineering Inc.	Wakfield, Mass.	21535	The Fafnir Bearing Co.	New Britain, Conn.	73076	H. M. Harper Co.	Chicago, Ill.	81095	Triad Transformer Corp.	Yonice, Calif.
06004	The Basicss Co.	Bridgeport, Conn.	21964	Fed. Telephone and Radio Corp.	Clifton, N. J.	73138	Helipot Div. of Beckman	Fullerton, Calif.	81312	Winchester Electronics Co., Inc.	Norwalk, Conn.
06175	Bausch and Lomb Optical Co.	Rochester, N. Y.	24446	General Electric Co.	Schenectady, N. Y.	73293	Hughes Products Division of	Newport Beach, Calif.	81349	Military Specification	Cleveland, Ohio
06402	E. T. A. Products Co. of America	Chicago, Ill.	24555	G. E., Lamp Division	Nela Park, Cleveland, Ohio	73445	Amperex Electronic Co., Div. of North	Hicksville, N. Y.	81453	Wilcox Products, Inc.	Industrial Components
06540	Amalcan Electronic	New Rochelle, N. Y.	24555	Gies Reproduction Corp.	New Rochelle, N. Y.	73490	American Philips Co., Inc.	So. Pasadena, Calif.	81483	International Rectifier Corp.	Newton, Mass.
06555	Beebe Electrical Instrument Co., Inc.	Penacook, N. H.	24642	Grobel File Co. of America, Inc.	Carlsbad, N. J.	73506	Bradley Semiconductor Corp.	Hamden, Conn.	81541	The Asynap Products Co.	Cambridge, Mass.
06751	U. S. Sensor Division of Nuclear Corp.	Phoenix, Arizona	24840	Hewlett-Packard Co.	Palo Alto, Calif.	73559	Carling Electric, Inc.	Hartford, Conn.	81860	Berry Controls, Inc.	Watertown, Mass.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.	33173	G. E. Receiving Tube Dept.	Owensboro, Ky.	73692	George K. Garrett Co., Inc.	Philadelphia, Pa.	82042	Carier Parts Co.	Skokie, Ill.
07115	Corning Glass Works	Corning, N. Y.	33434	Lectrohm Inc.	Chicago, Ill.	73734	Federal Screw Prod. Co.	Chicago, Ill.	82142	Jeffers Electronics Division of	Speed Carbon Co.
07126	Digital Co.	Pasadena, Calif.	36196	Stanwhyn Corp.	Hawkesbury, Ontario, Canada	73743	Fischer Specialties Co.	Cincinnati, Ohio	82170	Allen B. DuMont Labs, Inc.	Clifton, N. J.
07137	Transistor Electronics Corp.	Minneapolis, Minn.	37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.	73793	The General Industries Co.	Elyria, Ohio	82209	Magure Industries, Inc.	Greenwich, Conn.
07138	Westinghouse Electric Corp.	Elmhurst, N. Y.	39543	Mechanical Industries Prod. Co.	Akron, Ohio	73846	Goshen Slamping & Tool Co.	Goshen, Ind.	82219	Sylvania Electric Prod. Inc.	Emporium, Pa.
			40920	Miniature Precision Bearings, Inc.	Keene, N. H.	73859	JFD Electronics Corp.	Brooklyn, N. Y.	82376	Astron Co.	East Newark, N. J.
			42190	Moler Co.	Chicago, Ill.	73905	Jennings Radio Mfg. Co.	San Jose, Calif.	82389	Swischcraft, Inc.	Chicago, Ill.
			43990	C. A. Norgren Co.	Englewood, Colo.	74276	Signalite Inc.	Neptune, N. J.	82647	Metals and Controls, Inc., Div. of	Texas Instruments, Inc.
			47904	Polaroid Corp.	Skokie, Ill.	74455	J. H. Wines, and Sons	Winchester, Mass.		Spencer Prods.	Attleboro, Mass.
			46620	Precision Thermometer and	Philadelphia, Pa.	74861	Industrial Condenser Corp.	Chicago, Ill.			
				last, Co.		74868	R. F. Products Division of Amphenol-	Danbury, Conn.			

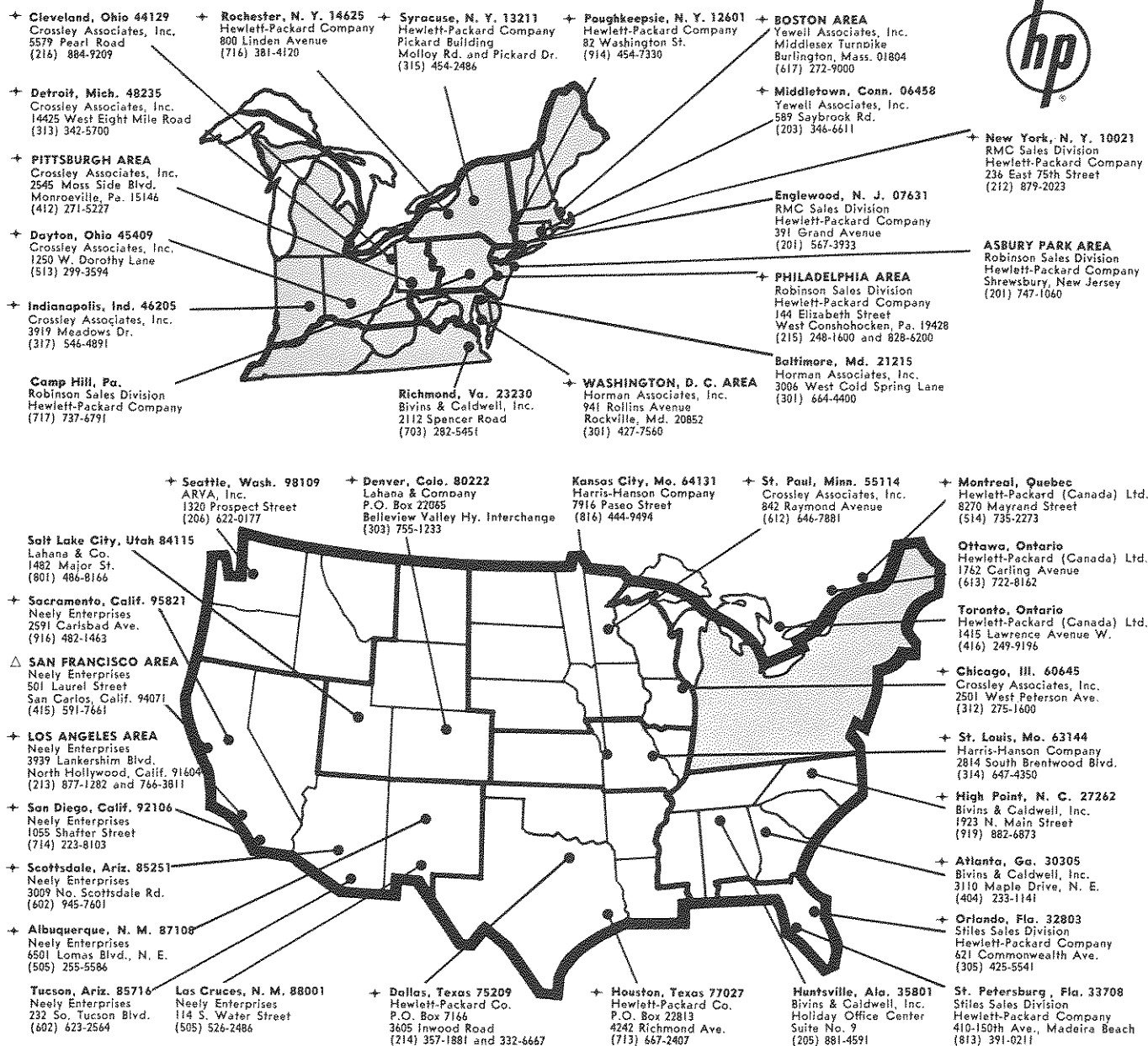
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H4-1 Dated OCTOBER 1963
H4-2 Dated MARCH 1962

APPENDIX **CODE LIST OF MANUFACTURERS (Sheet 2 of 2)**

Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address	Code No.	Manufacturer	Address
82866	Research Products Corp.	Madison, Wis.	89636	Carier Parts Div. of Economy Baler Co.	Chicago, Ill.	95263	Leecraft Mfg. Co., Inc.	New York, N.Y.	THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.		
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.				95264	Lercio Electronics, Inc.	Burbank, Calif.			
82893	Vecton Electronic Co.	Glendale, Calif.	89665	United Transformer Co.	Chicago, Ill.	95265	National Coil Co.	Sheridan, Wyo.			
83053	Western Washer Mfr. Co.	Los Angeles, Calif.	90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.	95275	Vibronon, Inc.	Bridgeport, Conn.			
83058	Carr Fastener Co.	Cambridge, Mass.				95349	Gordas Corp.	Bloomfield, N.J.			
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.	90970	Bearing Engineering Co.	San Francisco, Calif.	95354	Methode Mfg. Co.	Chicago, Ill.	C0000	JFD Electronics Corp.	Van Nuys, Calif.
83125	Pyramid Electric Co.	Darlington, S.C.	91260	Connor Spring Mfg. Co.	San Francisco, Calif.	95967	Wickesser Co.	Chicago, Ill.	G0000	Tranex Company	Mountain View, Calif.
83145	Electro Conds Co.	Los Angeles, Calif.	91345	Mesier Dial & Nameplate Co.	El Monte, Calif.	95967	Higgins Laboratories	Sunnyvale, Calif.	10000	Western Devices, Inc.	Ingleswood, Calif.
83186	Victory Engineering Corp.	Union, N.J.	91418	Radio Materials Co.	Chicago, Ill.	96005	H-Q Division of Aerowox	Orlean, N.Y.	J0000	Winchester Electronics, Inc.	Santa Monica, Calif.
83296	Berdia Corp., Red Bank Div.	Red Bank, N.J.	91506	Augat Brothers, Inc.	Attleboro, Mass.	96256	Thomson-Morse Div. of Magure Industries, Inc.	ML, Carmel, Ill.	0000F	Malco Tool and Die	Los Angeles, Calif.
83315	Hubbell Corp.	Mundelein, Ill.	91637	Gale Electronics, Inc.	Columbus, Neb.	96296	Solar Manufacturing Co.	Los Angeles, Calif.	0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.	91662	Elco Corp.	Philadelphia, Pa.	96330	Carlton Screw Co.	Chicago, Ill.	0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
83385	Central Screw Co.	Chicago, Ill.	91737	Grenar Mfg. Co., Inc.	Wakefield, Mass.	96341	Microwave Associates, Inc.	Burlington, Mass.	0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.	91827	K F Development Co.	Redwood City, Calif.	96501	Excel Transformer Co.	Oakland, Calif.	0000W	Webster Electronics Co. Inc.	New York, N.Y.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.	91929	Minnesota-Honeywell Regulator Co., Microswitch Div.	Freeport, Ill.	97454	Industrial Retaining Ring Co.	Irvine, N.J.	0000Z	Willow Leather Products Corp.	Newark, N.J.
83740	Eveready Battery	New York, N.Y.	92180	Tru-Connector Corp.	Peabody, Mass.	97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.	0000A	British Radio Electronics Ltd.	Washington, D.C.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.	92196	Universal Metal Prod., Inc.	Bassett Puente, Calif.				000AB	ETA	England
83821	Loyd Scruggs Co.	Festus, Mo.	92367	Elgett Optical Co., Inc.	Rochester, N.Y.	97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.	000AC	Indiana General Corp., Elect. Div.	Indiana
84171	Alco Electronics, Inc.	New York, N.Y.	92607	Tinsolite Insulated Wire Co.	Tarrytown, N.Y.	97979	Reon Resistor Corp.	Yonkers, N.Y.	000AD	Curtis Instrument Inc.	ML, Kisco, N.Y.
84296	A. J. Gleason Co., Inc.	San Francisco, Calif.	93332	Sylvania Electric Prod., Inc., Semiconductor Div.	Woburn, Mass.	98141	Axel Brothers Inc.	Jamaica, N.Y.	000BB	Precision Instrument Components Co.	
84411	Good All Electric Mfg. Co.	Ogata, Neb.	93369	Robbins and Myers, Inc.	New York, N.Y.	98159	Rubber Tech, Inc.	Gardena, Calif.	000MN	Rubber Eng. & Development	Van Nuys, Calif.
84470	Sarkis Tarzian, Inc.	Bloomington, Ind.	93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio	98220	Francis L. Mosley	Pasadena, Calif.	000NN	A "N" D Manufacturing Co.	San Jose 27, Calif.
84544	Bouton Molding Company	Bouton, N.J.	93785	Howard J. Smith Inc.	Portsmouth, N.J.	98278	Microdot, Inc.	So. Pasadena, Calif.	000QQ	Cooltron	Oakland, Calif.
84571	A. B. Boyd Co.	San Francisco, Calif.	93929	G. V. Conhols	Livingston, N.J.	98405	Sealectro Corp.	Mamaroneck, N.Y.	000RR	Radio Industries	Des Plaines, Ill.
84574	R. M. Bracamonte & Co.	San Francisco, Calif.	93953	Insuline-Van Norman Ind., Inc., Electronic Division	Manchester, N.H.	98431	General Mills	Redwood City, Calif.	000SS	Control of Elgin Watch Co.	Burbank, Calif.
84660	Koiled Kords, Inc.	New Haven, Conn.	94137	General Cable Corp.	Bayonne, N.J.	98821	North Hills Electric Co.	Minneapolis, Minn.	000WW	California Eastern Lab.	Burlingame, Calif.
84911	Seamless Rubber Co.	Chicago, Ill.	94144	Raytheon Mfg. Co., Industrial Components Div., Receiving Tube Operation Quincy, Mass.		98925	Clevis Transistor Prod. Div. of Clevis Corp.	Meneola, N.Y.	000XX	Methode Electronics, Inc.	Chicago 31, Ill.
84917	Clifton Precision Products	Clifton Heights, Pa.	94145	Raytheon Mfg. Co., Semiconductor Div., California Street Plant	Newton, Mass.	98978	International Electronic Research Corp.	Burbank, Calif.	000YY	S. K. Smith Co.	Los Angeles 45, Calif.
84979	Precision Rubber Products Corp.	Dayton, Ohio	94148	Scientific Radio Products, Inc.	Loveland, Colo.	99109	Columbia Technical Corp.	New York, N.Y.			
84984	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.	94154	Tung-Sol Electric, Inc.	Newark, N.J.	99313	Varian Associates	Palo Alto, Calif.			
87216	Phlco Corporation (Lansdale Division)	Lansdale, Pa.	94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.	99515	Marshall Industries, Electron Products Division	Pasadena, Calif.			
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.	94222	Southern Div. of S. Chesler Corp.	Lester, Pa.	99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.			
87664	Van Waters & Rogers Inc.	Seattle, Wash.	94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.	99860	Delevan Electronics Corp.	East Aurora, N.Y.			
87930	Tower Mfg. Corp.	Providence, R. I.	94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.	99848	Wilco Corporation	Indianapolis, Ind.			
88140	Cutler-Hammer, Inc.	Lincoln, Ill.				99934	Renbrandt, Inc.	Boston, Mass.			
88220	Gould-National Batteries, Inc.	St. Paul, Minn.	95023	Philbrick Researches, Inc.	Boston, Mass.	99942	Hoffman Semiconductor Div. of Hoffman Electronics Corp.	Evanston, Ill.			
88698	General Mills, Inc.	Buffalo, N.Y.	95236	Allies Products Corp.	Miami, Fla.	99957	Technology Instrument Corp of Calif.	Newbury Park, Calif.			
89231	Graybar Electric Inc. Co.	Oakland, Calif.	95238	Continental Connector Corp.	Woodside, N.Y.						
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Tel: 23-4129

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WARRANTY

All our products are warranted against defects in materials and workmanship for one year from the date of shipment. Our obligation is limited to repairing or replacing products (except tubes) which prove to be defective during the warranty period. We are not liable for consequential damages.

For assistance of any kind, including help with instruments under warranty, contact your nearest Hewlett-Packard field office for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, *except transportation charges*. Estimates of charges for non-warranty or other service work will always be supplied, if requested, before work begins.

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Your instrument should be inspected and tested as soon as it is received. The instrument is insured for safe delivery. If the instrument is damaged in any way or fails to operate properly, file a claim with the carrier or, if insured separately, with the insurance company.

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On receipt of shipping instructions, forward the instrument prepaid to the destination indicated. You may use the original shipping carton or any strong container. Wrap the instrument in heavy paper or a plastic bag and surround it with three or four inches of shock-absorbing material to cushion it firmly and prevent movement inside the container.

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